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SPECIAL CATALOGUE

OF THE

JOINT EXHIBITION

OF GERMAN

MECHANICIANS AND OPTICIANS

Délégué-Représentant à l'Exposition :
Robert DROSTEN, Bruxelles
Dépôt général aux prix de fabriques
des meilleurs constructeurs allemands.

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List of Exhibitors.

On this auspicious occasion, when the great French nation has invited the peoples of the world to inaugurate the 20th century by joining together under her hospitable sky in a brilliant exhibition of the works of peaceful competition, it would not seem irrelevant to glance back upon the departed century. It has been essentially an age of scientific and technical development and, naturally, the mechanical and optical trades claim a prominent share in the progress of mankind within the last hundred years. If we compare our present fundamental basis of all scientific measurements, our weights and measures, in their present perfection, with those existing a hundred years ago; if we place our finest astronomical and surveying instruments side by side with the, to us almost primeval, forms as they existed at the beginning of the century; or if we glance at our present sensitive physical and electrical measurements, remembering that a hundred years ago these were undreamt-of things, or in existence only in the crudest form, we cannot escape from a gladdening appreciation of the enormous progress made within the last century in the construction of philosophical instruments as well as their reaction upon the progress of scientific investigations by dint of improved methods. A prominent share in this development of the aids of science is due to the German Mechanicians and Opticians.

At the commencement of the 19th century, the French and English makers of scientific instruments were far in advance of the Germans. True, the 18th century knew of prominent mechanicians, and at the very beginning of the 19th century Fraunhofer and Reichenbach and their disciples, Repsold of Hamburg, Pistor of Berlin and others, had secured general respect, in the scientific world, for German mechanical skill; yet the French and English makers took the lead at that time, so as to almost supply the world's entire demand in scientific instruments. This predominance had the further consequence of causing young Germans to emigrate to France or England in order to thoroughly master their subject. Many a German mechanician of the present day owes to French or English masters a substantial portion of his knowledge and even in these days it is the aspiration of many a Teuton to widen his practical knowledge in France or England. The prominent position of the French and English instrument-makers was mainly due to the support which in both countries the State bestowed upon technical art. In England, the interests of the Navy and Merchant-service gave rise to the assiduous development of astronomical and nautical measuring instruments, more particularly of astronomical chronometers, so as to ensure in these branches an absolute supremacy, which German mechanicians

have only within the last ten or twenty years been able to contest. France owed her prominent position to the great geometrical survey of Cassini and his followers and, in a still greater degree, the admirable comprehensive labours leading to the establishment of the metrical system of weights and measures, which in its turn resulted in far-reaching improvements in the construction of appliances for weighing and measuring, astronomical and surveying, physical und chemical instruments.

In Germany, it is only within the last twenty or twenty-five years that the State has espoused the interests of the home industry in scientific instruments, but such have been the efforts and the results that the position has, at a blow, as it were, changed in favour of Germany. Every possible encouragement was offered and great problems were created by the expenditure of the German governments, within the last thirty years, on art and science, the establishment of numerous large physical and chemical laboratories, the erection and the expansion of old observatories, the requisition of greatly improved surveying and astronomical instruments. Great progress resulted from the introduction of the metric system in the construction of exact weights and delicate balances and, in compliance with the requirements of modern meteorology, led to vast improvements in thermometry and barometry. The development of the German navy created a great demand for nautical instruments. All these influences roused the productive powers of the nation and success has not been wanting.

Soon also the necessity was recognised of the close co-operation of the scientists and practical men. Accordingly, in 1879 several scientists, mechanicians and opticians united in Berlin and formed the nucleus of the German Association of Mechanicians and Opticians, which was formed in 1881 and embraced the whole German Empire, having for its object the scientific, technical and commercial development of philosophical instrument making. The official organ of this Society, the Zeitschrift für Instrumentenkunde, was likewise founded in 1881 and is devoted to the theoretical and practical development of scientific instruments. Specialized schools were established, first in Berlin, then in Frankfort-on-the-Main and subsequently in many other towns, where savants and practical men are combined in training the rising generation in the theoretical departments of the subject. As a result of these serious scientific aims, German mechanicians and opticians sought in their laboratories and workshops the assistance of scientists, and at the present time the majority of the leading German firms retain one or more experienced mathematicians or physicists in their permanent service.

The greatest share of the impetus given to the manufacture of scientific instruments, however, is due to the Imperial Physical and Technical Institute, which was established in 1887. The first, or scientific, department of this important institution is devoted to purely physical research, whilst the second, or technical, department deals with matters concerning the construction of philosophical instruments. This institution has already done great service and a large proportion of recent progress is due to its stimulating and helpful influence.

Seeing how comprehensive and systematic are the efforts brought to bear upon the art and science of instrument-construction, it is not surprising that in this department Germany occupies now a foremost position. This fact was already apparent on the occasion of the Universal Exhibition of 1888 at Brussels, even more strikingly so at the World's Columbian Exhibition at Chicago in 1893, and remarkable achievements were shown by the combined members of the German Association of Mechanicians and Opticians at the Berlin Trades Exhibition of 1896.

After witnessing this steady development of our mechanical and optical trade, we cannot but look with confidence and gratification upon the practical demonstration at the Paris Centenary Exhibition of the flourishing state of the scientific instrument trade in Germany, and a characteristic feature of the latter is the unity of its aims, which is traceable to the history of its development and its intimate connection with pure science. It appeared, therefore, desirable to depart from the usual custom of grouping the exhibits under various firms and rather to place them into sections embracing certain classes of instruments so as to demonstrate on broad lines and as a whole, within a well arranged though condensed area, the present position of German mechanical and optical art.

The Joint Exhibition of German Mechanicians and Opticians is, accordingly, subdivided into the following sections:—

I. Metrological and Standardizing Instruments.

II. Astronomical Instruments.

III. Surveying and Nautical Instruments:—a. Geometric instruments, b. Surveying, mining and exploring instruments, c. Nautical instruments.

IV. Meteorological, Geo-magnetic, Thermometric and Calorimetric Instruments.

V. Optical Instruments:—a. Photometrical Appliances, b. Spectroscopes and Optical Measuring Instruments, c. Microscopes and their auxiliaries, d. Photomicrography and Projection, e. Photographic Ojectives, f. Hand-telescopes and Terrestrial Telescopes, g. Crystalloptics, Appliances for demonstrating and observing the Phenomena of Light.

VI. Electrical measuring instruments for Scientific Purposes.

VII. Electro-medical, Physiological and Biological Instruments.

VIII. Appliances for Chemical and Chemico-physical Research, Laboratory and Educational Apparatus.

IX. Drawing and Calculating Appliances.

X. Appliances for the Examination of Materials and for Special Purposes, Special Tools and Auxiliaries.

Following the plan of grouping the exhibits into sections according to subjects of applied science, it may be profitable to append a short sketch of the present position of philosophical instrument-making in Germany.

I. German mechanicians found themselves for the first time in their history face to face with a task of some magnitude when called upon, some seventy years ago, to construct metrological and standardizing appliances for the purpose of determining, under the direction of the great astronomer Bessel, the standards of the old Prussian system of measures. Subsequently, the mechanical arts received an important impetus through the introduction of the metric system in general and the influence and requirements of the Standardizing Commission in particular. The numerous inducements and hints which German mechanicians have received from the Standardizing Commission have enabled them to effectually co-operate in the introduction of the metric system both in and outside Germany. Opportunities presented themselves for the construction of very exact comparators, dividing engines, terminal and divided measures, balances of the highest degree of precision, &c.; and while acquitting themselves of these tasks, German mechanicians have both learned and accomplished much. A considerable portion of the equipment of the Bureau international des poids et mesures has proceeded from German workshops. The achievements of Germany in the department of metrological instruments and appliances are prominently demonstrated within the Joint Exhibition of Mechanicians and Opticians by the Special Exhibits of the Imperial Normal-Aichungs-Kommission (Office of Standards).

II. From the measures, the indispensable fundament of all exact research, we proceed to the astronomical instruments. This department is necessarily at a disadvantage inasmuch as the largest and most costly instruments, the large refractors, can only be exhibited under very special circumstances. Hitherto German telescope-makers have supplied large refractors almost exclusively to countries outside Germany, but in this respect they have actively competed with other makers. Recently they have been given an opportunity of proving their powers in the construction of the new Potsdam refractor, which is not only one of the largest instruments in Europe, but also the first large telescope built for a German observatory, and the results have been brilliant indeed. In the main, the German makers have devoted their attention to the construction of medium-sized and small astronomical instruments, refractors, transit-circles, altitude circles, heliometers, &c., but with such success that, as regards the precision and delicacy of the individual parts of the instrument, Germany stands now unrivalled. Recently great progress has been made in the construction of astronomical objectives. The first optician who broke the ice in the important department of optical glass smelting was a German, to wit Fraunhofer. His untimely death was followed by a long period of stagnation, and the limits of the possible were soon reached when attempts were made to construct very large objectives, at least as far as the optician's art was concerned. About twenty years ago, Prof. Abbe and Dr. Schott, of Jena, resumed the thread where Fraunhofer had left off, and they succeeded in producing the old crown and flint-glasses in such perfection that the chromatic differences of spherical aberration can be compensated almost completely. This led to great

improvements in telescope lenses, and at the same time the Jena Glass Works have become so productive as to enable German opticians to cover their entire demand in Germany. Great progress has also been made in such an important branch of manufacture as that of spirit-levels. Not only are the finest spirit-levels incontestably made in Germany, but, in addition, the Imperial Physical and Technical Institute has successfully investigated the causes of the formation of deposits within the levels. Mechanicians possess now a ready means of detecting glass liable to deterioration and have no difficulty in securing suitable glasses.

III. The third section, comprising geometric and nautical instruments, includes also those instruments which form a connecting link between astronomy proper and the land-surveyor's art, i. e., those astronomical instruments which are employed for geodetic measurements. Many improvements in this group of instruments have emanated from German workshops and have had their origin in the requirements of the International Survey and especially the influence of the Geodetic Institute and its present director, Dr. Helmert. We may here mention the conversion of the friction-rollers of transit instruments into a balance beam, so as to completely compensate the errors of collimation. We may also refer to Repsold's mode of fitting transit instruments so as to almost entirely neutralize the personal equation, and equally important are the improvements in zenith-telescopes and spirit-level testing appliances. The geophysical investigations of the International Survey have given birth to the most sensitive instrument of our times, the horizontal pendulum, which owes its origin and development to German scientists and mechanicians. The study of the movements of the oceans has recently been facilitated by greatly improved instruments, the most perfect of which are those of Seibt-Fuess. Remarkable progress has in late years been made in the construction of surveying instruments. The requirements of surveyors and engineers have reached such a high stage of development that they could not fail to beneficially affect the construction of theodolites, levelling instruments and tacheometers. The manufacture of surveying instruments is carried on in Germany on a very extensive scale, and the reputation of these instruments has obtained for them a wide market all over the world. Considerable improvements have also been made in small compactly built surveying instruments, which have been requisitioned by numerous German explorers. As the natural outcome of the developments of the merchant service and the creation of a powerful navy, considerable attention is paid to the manufacture of nautical instruments. Whereas formerly Germany depended for these accessories of navigation upon other countries, England in particular, at the present time all nautical instruments are manufactured at home equally well, in some respects even better than abroad.

IV. The development of the meteorological instruments and the appliances for measuring temperatures presents a typical illustration of the close connection between theoretical science and manufacture in Germany. This applies in particular to thermometers. About twenty years ago the manufacture of thermometers had come

to a dead stop in Germany, thermometers being then invested with a defect, their liability to periodic changes, which seriously endangered German manufacture. Comprehensive investigations were then carried on by the Normal-Aichungs-Kommission, the Imperial Physical and Technical Institute and the Jena Glass Works and after much labour brought the desired reward. Chemical analysis in conjunction with carefully managed glass smeltings and practical tests showed that pure potassic and pure sodic glasses possess those defects in the least degree, whereas glasses containing both alkalis are subject to periodic changes to such an extent as to render them useless for thermometric purposes. The last outcome of these investigations was the production, at the Jena Glass Works, of an excellent sodium glass, which shows depressions of not more than 0·1° per 100°. Recently a boro-silicate glass has been prepared which shows a maximum depression of only 0·05° and possesses, moreover, the important property of excellently agreeing with the hydrogen thermometer. The advantages which may result from these discoveries to meteorology as well as the physical, chemical and medical sciences, are obvious. The technical arts too have benefited by discovery. With the aid of the new glasses and the invention of a process by which mercury is kept in the thermometer under a pressure of from 20 to 25 atmospheres, thermometers have been constructed for temperatures up to, and beyond, 550° C., as far as the region of incipient red heat, and reading accurately to $^{1}/_{10}$°. In consequence of these systematic efforts the manufacture of thermometers has reached in Germany an unprecedented level, and now governs the market of the world. German thermometers are purchased everywhere with particular confidence, as they can be supplied with official certificates. The Thermometer Testing Institute of Ilmenau examines annually about 40,000, and 16,000 are annually tested by the Imperial Physical and Technical Institute.—German barometers, mercurial as well as aneroid, enjoy a high reputation and are everywhere esteemed for their delicate workmanship and reliability. The aneroid-barometers, which have obtained increased importance through the requirements of explorers, are tested by the Imperial Physical and Technical Institute with respect to their liability to periodic changes. The merits of the German self-registering instruments of the Sprung-Fuess type, thermographs and barographs, anemometers and rain-gauges are so well known that they need no further comment. These excellent instruments are used in all the meteorological observatories of the world. Finally, attention should be drawn to the pyrometers and calorimeters, which have also been considerably improved in recent years.

V. Like the mechanical arts, optical construction has made great and rapid progress in Germany. In this connection it is our gratifying duty to mention the name of Abbe, whose master-mind has had a profound influence upon the development of German optical science and manufacture. Abbe's earliest great merit is the elucidation of the theory of the microscope, by which he has placed microscopical optics upon an entirely new basis. It is also due to his efforts, in conjunction with those of Dr. Schott, the head of the Jena Glass Works, that numerous optically valuable

glasses have been rendered available for the purposes of optical construction and that many difficult problems have now been solved. The new Jena phosphate and baryte glasses have led to many improvements in microscopical optics. We need only refer to the Zeiss Apochromatic objectives, which, in conjunction with the compensating eyepieces, yield a much more perfect correction of the chromatic and spherical aberrations than was previously attainable. We believe that we are not going too far by saying that to Prof. Abbe is due the world-wide fame of German microscope construction. This reputation is not limited to the microscope itself, but all its accessories, and embraces also microtomes, photo-micrographic and projection appliances and, in particular, photographic objectives, the construction of which has undergone wonderful changes since the introduction of the Jena glasses. The enormous exigencies of modern artificial illumination has given rise to many improvements in photometry. In this department the path has been smoothed by the efforts of the Imperial Physical and Technical Institute, and photometers are now made by which the intensity of a luminary can be measured with a degree of accuracy within $\frac{1}{2}$ per cent. The result is that German photometers enjoy a predominant popularity.—Germany, the cradle of spectrum analysis, occupies naturally an important position in the manufacture of spectrum appliances. The construction of these instruments, varying from the largest and finest spectrometers for astronomical, physical and chemical research, to the smallest hand spectroscopes, employs a large number of establishments. The same applies to the manufacture of polariscopic appliances, which have a wide reputation and command a particularly large market in the sugar trade.—No less importance attaches to the optical measuring instruments designed for the special requirements of physicists, chemists, mineralogists, &c., which are made with astronomical precision, so as to satisfy the highest exigencies of modern research. Among these we may mention the crystalloptic instruments and those for studying the theory of the nature of light.—In the construction of telescopes Germany has, in addition to general improvements, achieved a triumph, which has given her a great advantage. We are referring to the new form of binocular telescopes, in which, by the interposition of prisms, the dimensions of terrestrial telescopes are reduced to their lowest limits, while, at the same time, the defining power, light-gathering power and the stereoscopic effect is greatly increased as compared with the older types. The invention of these telescopes has created a wide demand in the army and navy. Very considerable too is the industry in optical auxiliaries, prisms, quartz and calc-spar preparations, &c., in which Germany excels both in quality and productiveness.

VI. The manufacture of electrical measuring instruments for scientific purposes has, in Germany, kept pace with the great strides made in electrical engineering. A number of prominent firms apply themselves to this technical branch and have made themselves a good name. This industry has likewise profited by the fundamental labours of the Imperial Physical und Technical Institute, in particular by the

establishment of standards and by important investigations. We may here mention the introduction of new resistence materials, called manganine and constantan, which are not affected by changes of temperature and are now introduced by nearly all German firms occupied with the manufacture of electrical measuring instruments. Mention should also be made of the work accomplished in standard cells, which facilitate the application of the so-called methods of compensation for accurately measuring the strength and E. M. F. of electrical currents. This is, therefore, another department where the influence of scientific research has been felt in practical manufacture.

VII. Electro-medical appliances are also made in Germany and exported abroad in very large numbers. The growing application of the electric current as a curative agent in operations and for the illumination of internal cavities of the human body have caused this department of industry to develop considerably both technically and commercially. To this group of appliances belong the various kinds of Roentgen ray apparatus, which are made and exported in stupendous numbers. Great importance attaches also to the manufacture of physiological and biological instruments, which engages the attention of several prominent firms.

VIII. The manufacture of educational appliances has grown in proportion to the development of the methods of practical demonstration in elementary as well as intermediate schools and technical colleges. The German output of educational appliances has at present reached a truly astounding magnitude. This is mainly due to their cheapness, simplicity and their suitable size. The laboratory appliances required for scientific investigations comprise naturally the finest and costliest instruments made.

IX. The manufacture of drawing and calculating instruments employs a large number of German mechanicians. Excellent drawing instruments and other appliances for drawing, cartography, &c. are exported to all parts of the world. German mechanicians have likewise succeeded in considerably improving Thomas's old calculating machine.

X. In addition to purely scientific instruments, a very large number of appliances are in constant requisition for special industrial purposes, and many a mechanician finds constant employment in this department. Besides, much thought and skill is brought to bear upon the needs of mechanical workshops. Formerly every mechanician made his own tools, and in many instances this is still done. Many changes have, however, been wrought in this respect by the influence of the American system of manufacture, in which, it should be added, Germans have a considerable share. Prominent mechanicians and engineers began to devote themselves more or less exclusively to the manufacture of special tools for philosophical instrument making, and now form an important independent branch of industry.

In conclusion, we have to draw attention to the separate exhibition of the Imperial Physical and Technical Institute, which could not be mortised into the general

plan of the Joint Exhibition. The aims of this Institute, the greatest of its kind in the world, have already been explained. The exhibits of the Institute serve to illustrate in a concise form several spheres of its activity.

The commercial importance of the mechanical and optical trade of Germany is commensurate with its reputation, as will readily be seen from the following table showing the export of scientific instruments during 1898:—

	Nett weight kilos	Value in Marks
Astronomical, optical, mathematical, physical and electrical instruments	218,900	8,975,000
Raw optical glass (flint and crown)	124,900	625,000
Optical glasses (spectacles, reading-glasses, stereoscope glasses)	224,200	3,139,000
Terrestrial telescopes, field-glasses, opera-glasses, mounted spectacles, &c.	33,900	1,526,000
Total	601,900	14,265,000

The export has been trebled within 10 years!

Another measure of the magnitude of the mechanical and optical trade of Germany may be obtained from the number of manufacturing establishments and their employés. These are at present as follows:—

Nature of manufacture	Number of establishments	Number of persons employed
Astronomical, optical, mathematical, physical and electrical instruments	500	9,200
Glass-blowing, glass instruments, glass thermometers	125	1,773
Optical instruments, spectacles, reading-glasses	165	2,652
Total	790	13,625

I. Metrological and Standardizing Instruments.

1. Imperial Normal-Aichungs-Kommission, Berlin.

(Imperial Office of Standard Weights and Measures.)

The Imperial Office of Standard Weights and Measures was instituted by Article 18 of the law of the 17th of August 1868 relating to the weights and measures of the North German Confederation, which by § 2 of the law of the 16th of April 1871 concerning the constitution of the German Empire became Imperial law. This Office is composed of a permanent staff and a committee, meeting annually or at shorter intervals according to exigencies, of eminent authorities on theoretical and applied science. The Office is presided over by a director and includes at present amongst the members 3 Government councillors, 24 technical officials and about 10 clerks. A new official building providing space for 90 offices is in course of erection. The Office is maintained at an annual expenditure of Marks 170,000 (£8500).

The work of the Office is subdivided in three sections, known as the Scientific, Standardizing and Excise Departments.

Upon the Scientific Department devolves the task of permanently safeguarding, in Germany, the fundamental metrological data for the determination of weights and measures of length. This is mainly effected by continuous comparison of the standard weights and measures in the possession of the Office with their official prototypes and by controlling the standards of excise offices as well as those possessed by scientific and technical institutions and executive authorities. In connection with these duties, the Office aids in the development of the appliances and methods available for scientific research. For this purpose the Imperial Office of Standard Weights and Measures is provided with a complete equipment of the finest measuring instruments, such as comparators, balances, &c., some of which will be found among the exhibits.

The Standardizing Department attends to all matters concerning the technical side of the question and is responsible for the uniformity of the methods of standardizing throughout the Empire. This department also issues detailed orders respecting the regulation of weights, measures, balances and gauges, gasmeters, alcoholometers, hydrometers, saccharimeters, fluid measuring appliances, chemical measuring apparatus, &c. The scope of its duties includes also the preparation and distribution of the standards to the Excise Offices of the Empire and the regulation of the methods of testing, as well as the task of ensuring uniform compliance with regulations respecting weights and measures.

The work of the Excise Department aims at the establishment and permanent maintenance of the requisite degree of conformity between the technical appliances employed by the customs and excise authorities and the methods followed in their application. This work comprises the certification of the appliances used for testing spirits, spirit methylators, vinegar, liqueurs, fruit juices, ethereal oils, extracts, diluted wines, musts, &c.; it also embraces the attestation of the spirit measuring appliances employed in spirit distilling and the issue of the requisite technical instructions and tables.

1. Universal Comparator. This Instrument has been made by Hans Heele and J. Wanschaff, of Berlin, and consists of two separate parts, one of which is for the purpose of comparing measures having a length of one metre, while the other is available for comparing measures not exceeding four metres in length.

The microscopes are immovably mounted upon brick-pilars built upon independent foundations and covered with slabs of sandstone. The measures which are to be compared together with the troughs carrying them are successively placed under the microscopes. The troughs rest upon carriages and can be adjusted by externally accessible micrometer movements in a longitudinal and transverse direction, as well as raised and lowered.

An entirely new feature is the arrangement for exchanging the measures. The carriages are driven electrically and run upon rails, the backward continuation of which lead to a turn-table situated in the centre of the comparator room. The position of two carriages is thus reversed by turning this table 180°.

All movements are accomplished automatically from external points. An electro-magnetic distance pointer indicates the position of two carriages and their exact position is recorded by signalling devices.

The general arrangement of the comparator and its appartenances is shown by a $^1/_5$ full size model, the original construction being represented by the brick-pillar of the comparator with the microscope foundations and one of the carriages.

In addition to the usual ocular micrometer microscopes the equipment of the apparatus includes specially constructed photo-micrographic appliances, by means of which the terminal lines of each of the measures can be photographed successively on the same plate, thereby entirely eliminating inaccuracies arising from the effects of heat radiating from the experimenter's body. The relative lengths of the rods is determined by micrometric measurement of the photograms. One of the photo-microscopes will be found among the exhibits.

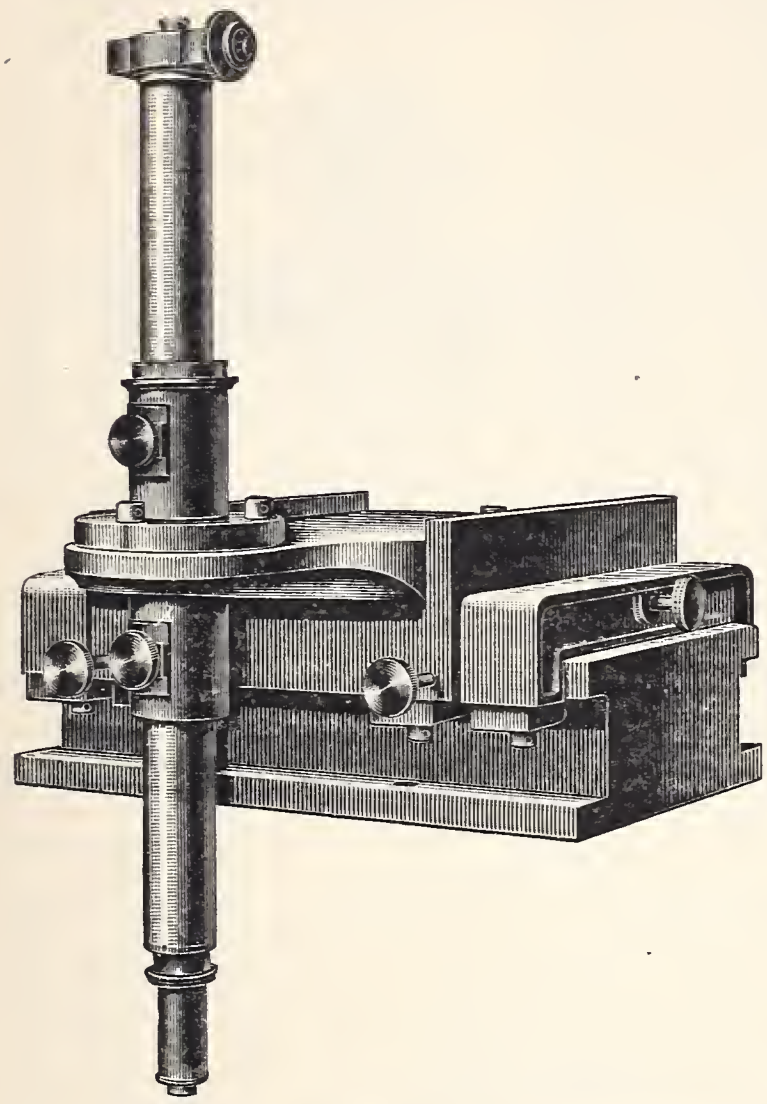


Fig. 1.

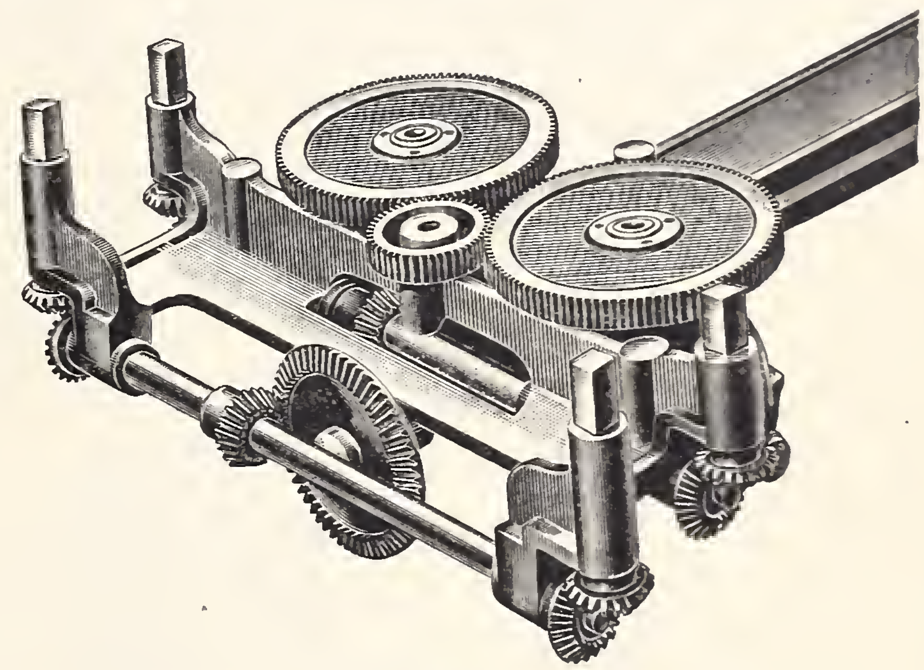


Fig. 2.

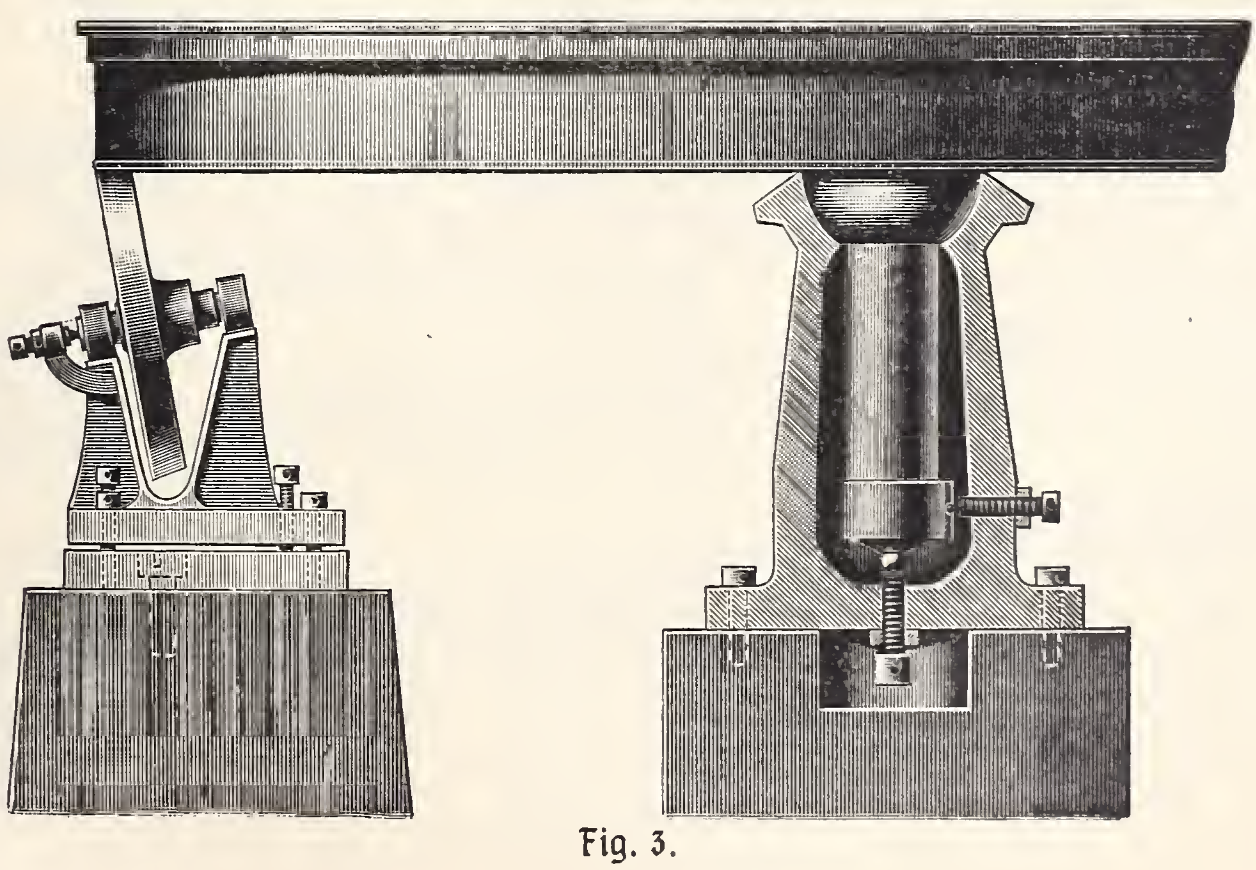


Fig. 3.

Fig. 1 shows the construction of the microscopes and the fittings serving for their adjustment. Fig. 2 represents a portion of the carriage together with the adjustments of the trough. Fig. 3 is a diagrammatical view of one side and the middle of the turn-table and its turning gear.

The Imperial Office of Standard Weights and Measures has published the following works on the subject of extremely fine measurements of length:—

1. Metronomischer Beitrag No. 5, Zur Geschichte und Kritik der Toisenmaassstäbe von C. F. W. Peters (History of and criticism on the toises measures by C. F. W. Peters), Berlin 1885, published by Ferd. Dümmler.
2. Wissenschaftliche Abhandlungen No. 1, II, Ueber den Anschluss des älteren Urmaasses und der Kopien desselben an das neue deutsche Prototyp für das Meter (On the relation of the old standard measures and their copies to the new German prototype of the metre), Berlin 1895, published by Julius Springer.
3. Mittheilungen der Kaiserlichen Normal-Aichungs-Kommission (Transactions of the Imperial Office of Standard Weights and Measures), Berlin, published by Julius Springer:—
   a) 1. Series No. 1, Thermische Nachwirkungen bei Metallen (Secular thermal changes in metals).

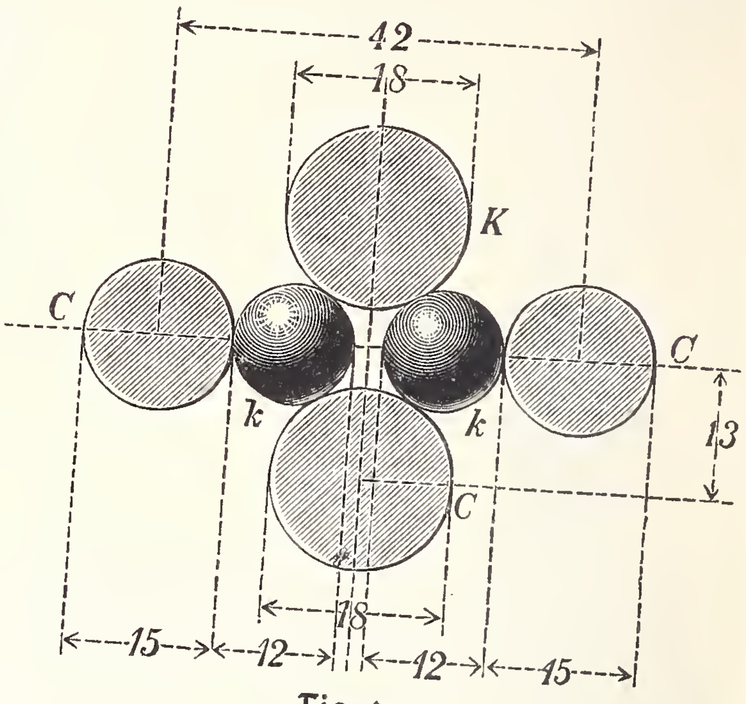


Fig. 4.

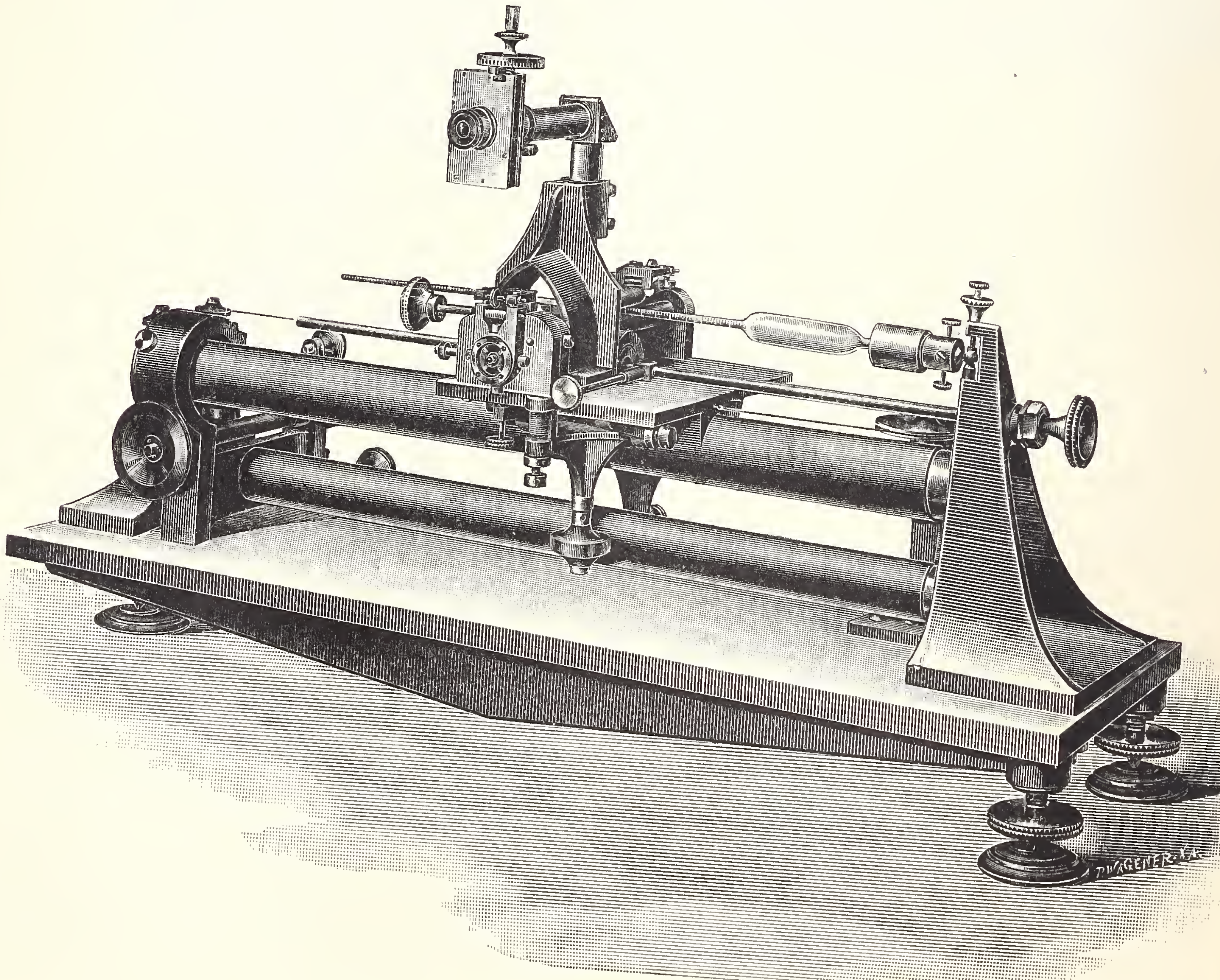


Fig. 5.

b) 1. Series No. 4, Beugungsgitter auf Metall unter starker Vergrösserung (Diffraction gratings on metal shown under high magnifications).
c) 1. - - 8, Einfluss der Feuchtigkeit auf die Längenausdehnung verschiedener Holzarten (The influence of moisture upon the longitudinal expansion of various species of wood).
d) 1. - - 9, Material der feineren Maassstäbe (Material for fine measuring rods).
e) 1. - - 9, Elastische und thermische Nachwirkungen bei Metallen (Elastic and thermal secular changes in metals).
f) 1. - - 10, Die Beziehungen der metrischen, der altfranzösischen und der englischen Längeneinheit zu einander (The relations of the metric, the old French and the English units of measure).
g) 1. - - 18, Erste periodische Prüfung der Kontrolnormale der Längenmaasse (First periodical examination of the controlling standards of the measures of length).
h) 1. - - 24, Ueber die Fehlerangaben für Maassstäbe, welche der Normal-Aichungs-Kommission zur Prüfung vorgelegt werden (On the defects of measuring rods submitted to the Imperial Office of Standard Weights and Measures for verification).

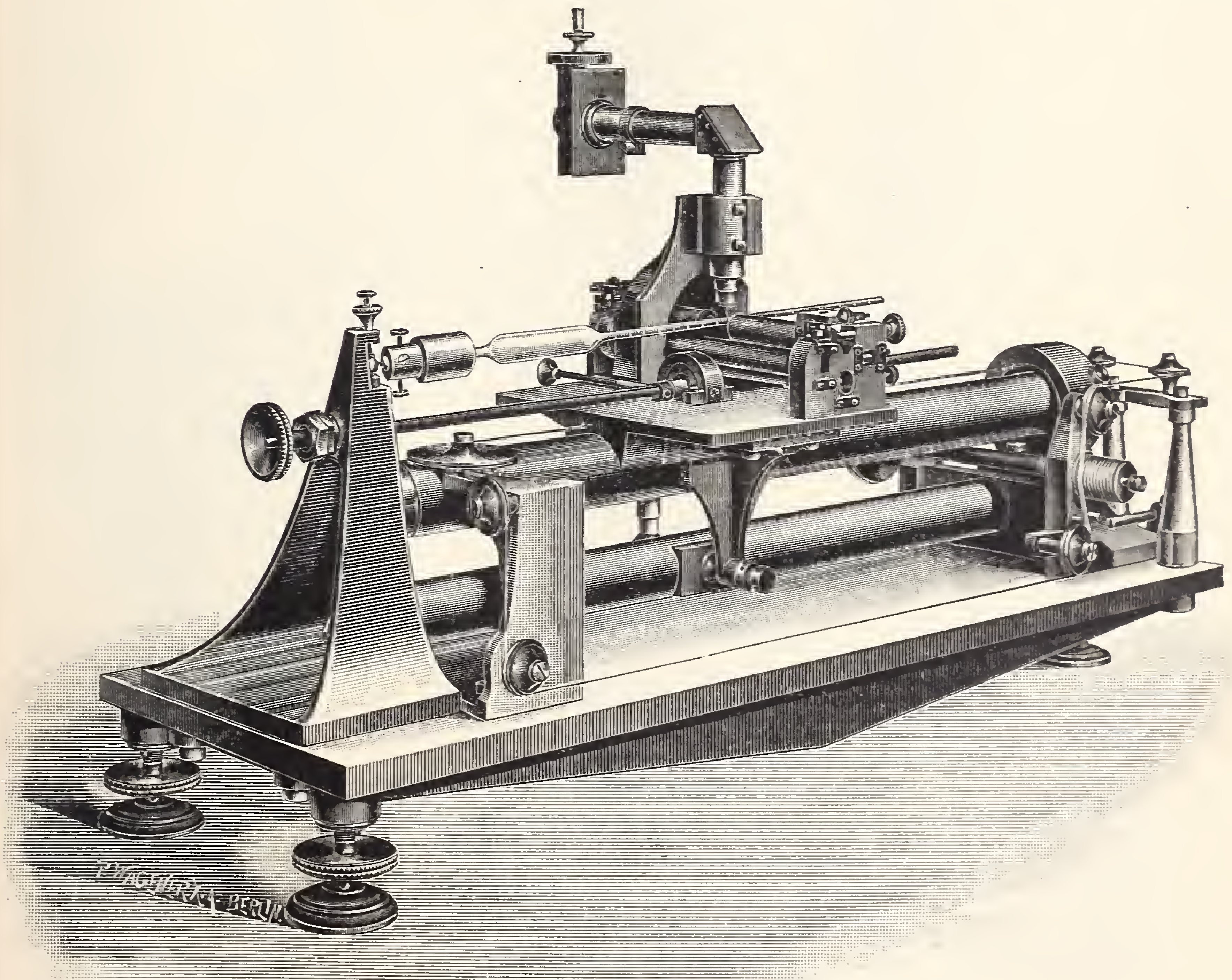


Fig. 6.

2. **Apparatus for measuring the thickness of hydrometers, wedges, cylinders, &c.** This apparatus, constructed by C. Reichel and H. Heele, of Berlin, was originally designed for the accurate determination of the cross-section of hydrometers at various points of their graduations, but

is available for many other uses. The apparatus consists of a cylindrical guide-rod upon which travels a slide-block, a second cylindrical rod keeping the latter from turning. The slide-block supports two contact cylinders which readily move at right angles to the track of the slide-block. These cylinders are fitted with knife-edges of sapphire and micrometer scales. The latter lie side by side when the knife-edges touch, but they are displaced when a hydrometer tube is placed between them. The amount of the mutual displacement is equal to the diameter of the tube and can be measured accurately within 0·0001 mm by means of a micrometer-microscope mounted above the scales on the side-block. The tubes which it is required to measure are placed parallel to the direction of motion of the slide-block in such a manner that they can be turned round their own axes. For this purpose the frame is fitted at one end with a universally adjustable holder. A novel feature of this apparatus consists in the frictionless movement of each of the contact cylinders on four balls of agate each of which rolls upon the sides of two cylinders. The whole of these balls are made to run on three truly parallel steel cylinders mounted upon the slide at right angles to the movement of the latter. In Fig. 4 C represents these steel cylinders, k the balls and K the contact-cylinders. The movements of the slide-block and the contact-cylinders are effected by special devices.

Figs. 5 and 6 illustrate the entire apparatus from different aspects.

The first apparatus of this kind ever made is described in the Metronomischer Beitrag No. 7, "Ueber die Bestimmung von Aräometern" (On a method of testing hydrometers) by Dr. B. Weinstein, Berlin 1880, published by Julius Springer.

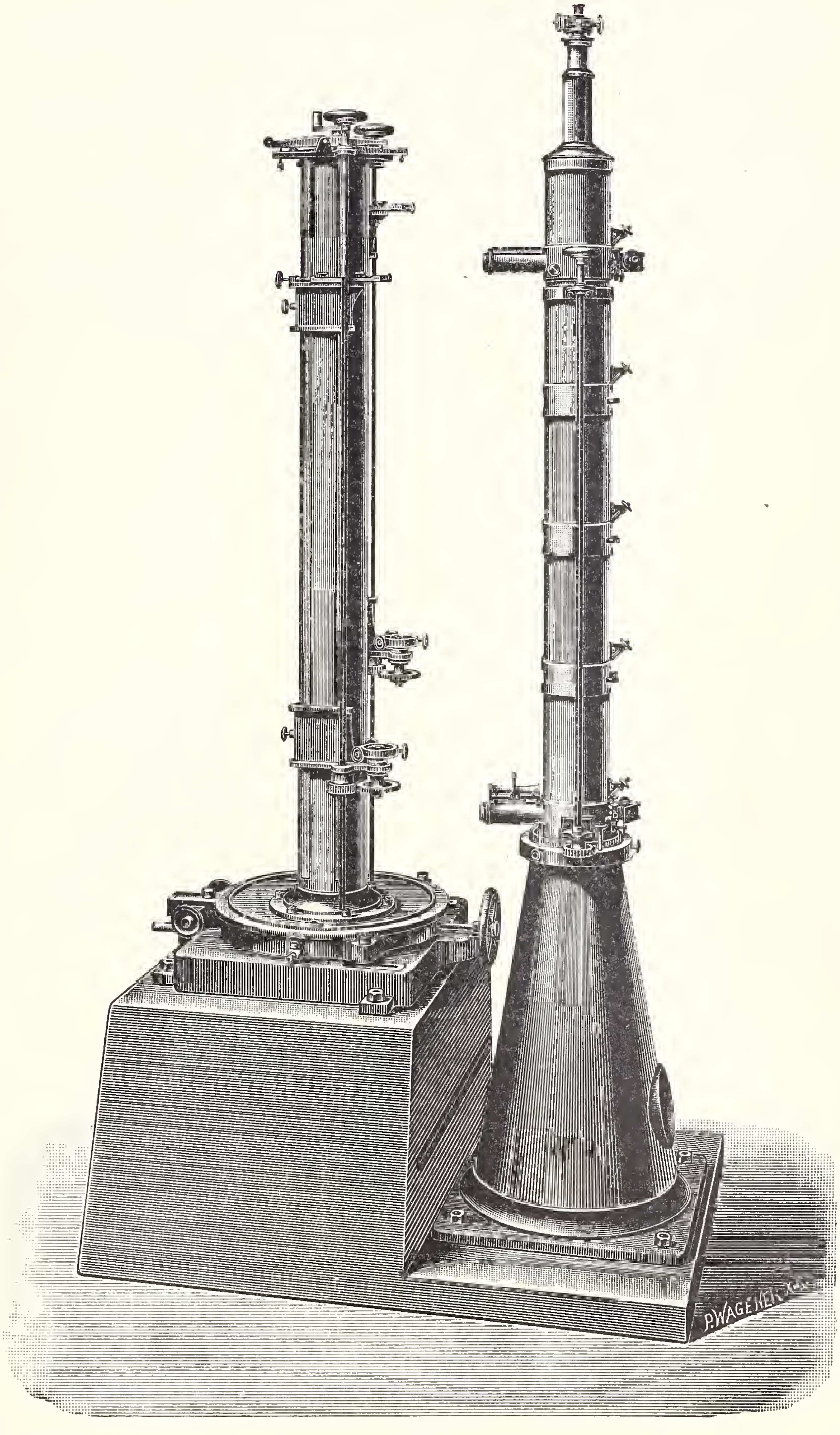


Fig. 7.

3. Vertical Comparator.

This comparator has

been constructed by A. Repsold & Söhne, of Hamburg, and serves for comparing divided measures and measuring pendulums in a vertical position. It will be seen from Fig. 7 that it consists of two separate parts mounted upon one pillar, viz: the micrometer tube with its microscopic reading appliances and the carrier of the measures under comparison. A new and distinctive feature of this apparatus consists in the optical and micrometric fittings.

The micrometer tube can be made to rotate on its vertical axes and carries at its upper end a micrometer in conjunction with an objective having the plane of its image coincident with that of the cross-lines. Another optical combination consisting of an objective and prism shows the terminal lines of the divided sections under comparison side by side in the micrometer. The distance between both images of these lines can be measured micrometrically and is equal to that section less the distance between the optical combinations referred to. The upper combination is permanently attached to the micrometer

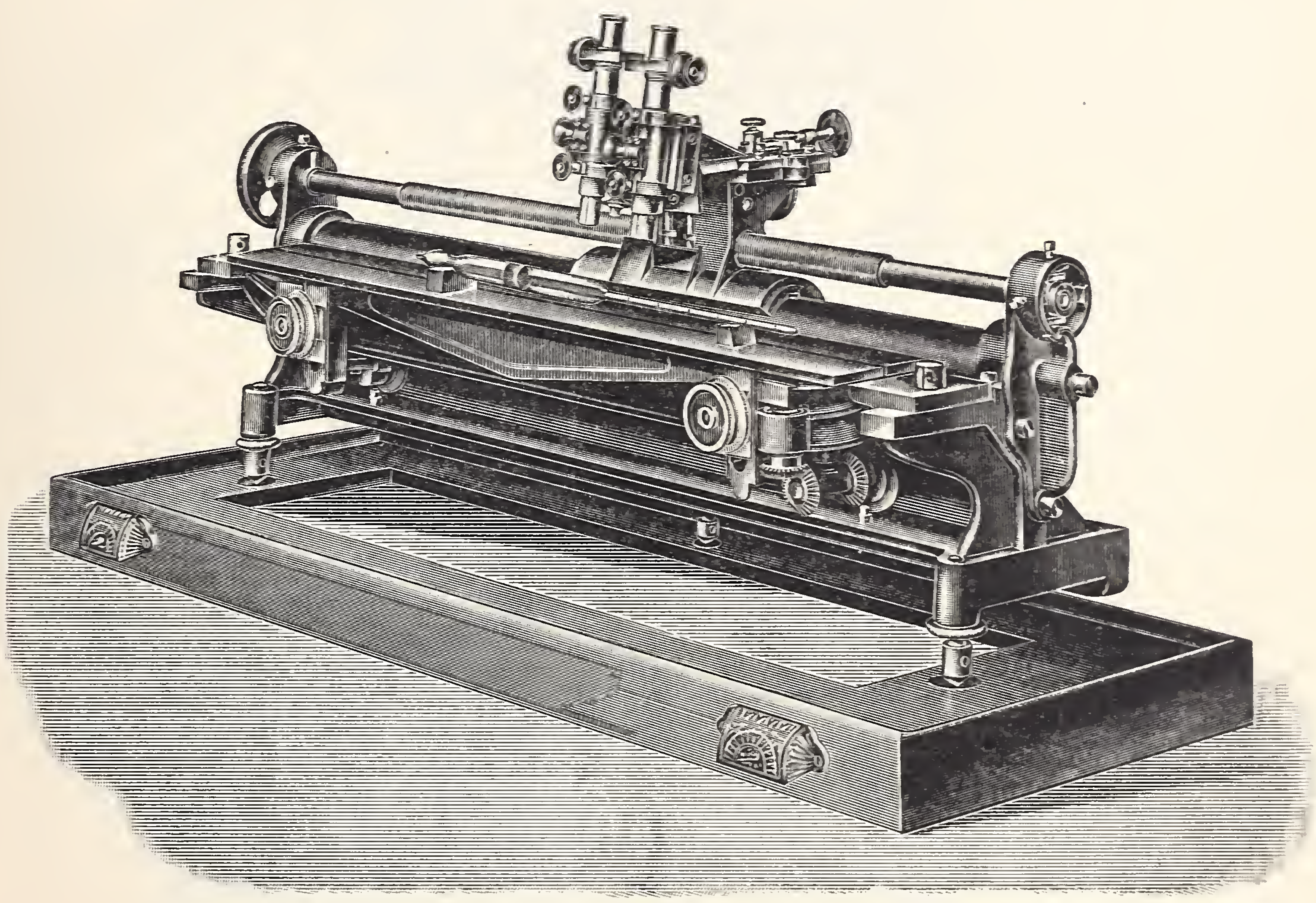


Fig. 8.

and together with it can be raised or lowered 20 mm; the lower combination can be moved and adjusted within the tube at distances of 0·25, 0·5, 0·75 and 1 m from the upper combination.

For the purposes of measuring the micrometer the casing is moved by means of an adjusting screw so as to cause a fixed pair of cross-lines in the casing to coincide with the image of one of the division lines. A movable pair of cross-lines is then, by means of the micrometer measuring screw, made to coincide with the other image of the division line, and the position of the micrometer drum is then noted. After turning the micrometer tube the process is repeated for the second rod.

The carrier of the rods consists of a movable sole-plate surmounted by a cast iron sleeve the planed sliding surfaces of which are fitted with movable and adjustable bearings adapted for the cylindrical end-journals of the rods. The weight of the rods can be taken up by means of two levers fitted to the upper end of the carrier. The sole-plate can be fitted with a watertight cylindrical jacket which is not shown in Fig. 7. The hollow part of the sleeve contains a stirring helix worked by a crank, so as to render the apparatus available for the measurement of immersed rods.

4. Longitudinal Screw Comparator. This comparator has been made by Sommer & Runge, of Berlin, for testing the graduations of thermometers, hydrometers, &c. It consists of a carrier fitted with two micrometer microscopes and sliding upon cylindrical rails, movement being imparted to it by a screw having a pitch of 1 mm. The latter is fitted with a drum divided into 100 parts and is adapted for measurements the precision of which do not exceed 0·01 mm. When measurements requiring a

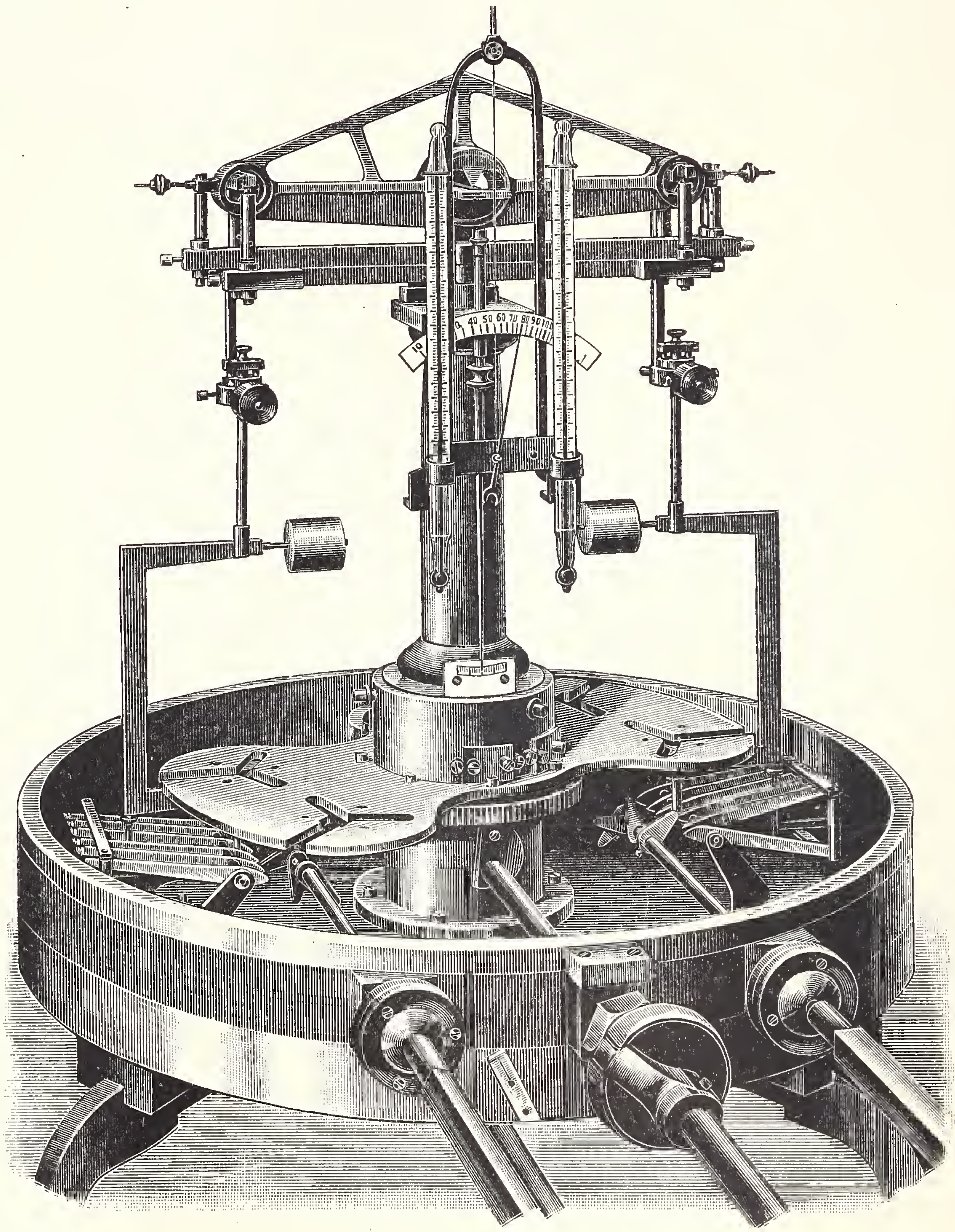


Fig. 9.

higher degree of precision are to be made this screw merely serves to impart a slow movement to the slide; in addition, the screw-nut can be thrown out of gear entirely. The actual measurement is effected by means of the eyepiece micrometer. One of the microscopes can, moreover, be moved a distance of 5 cm on separate cylindrical guides by means of a measuring screw. The measures which are to be compared are placed upon two plane cast iron tables which can be raised and lowered.

Fig. 8 shows the entire apparatus together with an instrument which is being tested.

5. Measures of Length.

a) Standard Metre Bronze Bar, made by C. Reichel, of Berlin. The rod is square in section, it has cylindrical turned ends and is fitted with rigidly mounted sapphire cones. The latter are polished by means of a machine specially constructed for this purpose, as described in Loewenherz's publication entitled, "Die wissenschaftlichen Instrumente auf der Berliner Gewerbe-Ausstellung 1879" (The Scientific Instruments shown at the Berlin Trades Exhibition of 1879), Berlin, published by Julius Springer. The ends of the sapphire cones are parallel and at right angles to the axis of the rod. The distance between their centres constitutes the length of the rod.

b) Standard Measuring Steel Bar, 2 m long. The rod and its ends are prepared as in the preceding case. In the centre the bar is bored and fitted in the neutral zone with a small glass disk having an auxiliary scale ruled upon it. The latter serves to deduce the total length of the one metre rod.

c) Scale divided within the neutral zone. The body of the scale is made of steel and forms a ⊢⊣ in section. The surface lying within the neutral zone is plane and finely polished, and the rod is thickly nickeled. The divisions are very fine and ruled upon the nickel coating by means of diamonds. During the process the formation of burrs has been carefully avoided so as to eliminate the necessity of subsequent finishing. The lines are 3 to 4 μ thick and free from ambiguity.

6. Vacuum Balance, made in 1894 by P. Stückrath, of Friedenau.

This balance serves for the purpose of comparing weights of 200 g to 1 kg and is mainly employed for weighing demanding the highest degree of accuracy. The beam, suspenders and cross-stirrups are of gilt brass; the knife-edges are of steel resting on agate planes. The balance rests upon a solid brass plate upon which is placed an airtight copper bell fitted with a small glass plate in the top and windows at the sides. This copper receiver takes the place of the bell glass covering the exhibit. The plate is fitted with stuffing-boxes through which are passed moving rods which can be manipulated by the experimenter 3 m away. These rods are fitted with suitable transmitters by means of which all necessary movements can be effected, such as the rotation, elevation and depression of the carrier, release of the beam and the suspenders, and the manipulation of the weights. The carrier is so arranged as to be available for comparing two pairs of weights. The additional weights are placed below upon the pans by means of racks, and when not in use hang upon levers which can be locked and released at pleasure by means of the side-rods. The interior of the balance is fitted with two thermometers and a hair hygrometer. The balance may be connected with an air-pump. The readings are taken in the usual manner by means of a prism and telescope fitted with a scale. Fig. 9 shows the entire general arrangement of the balance.

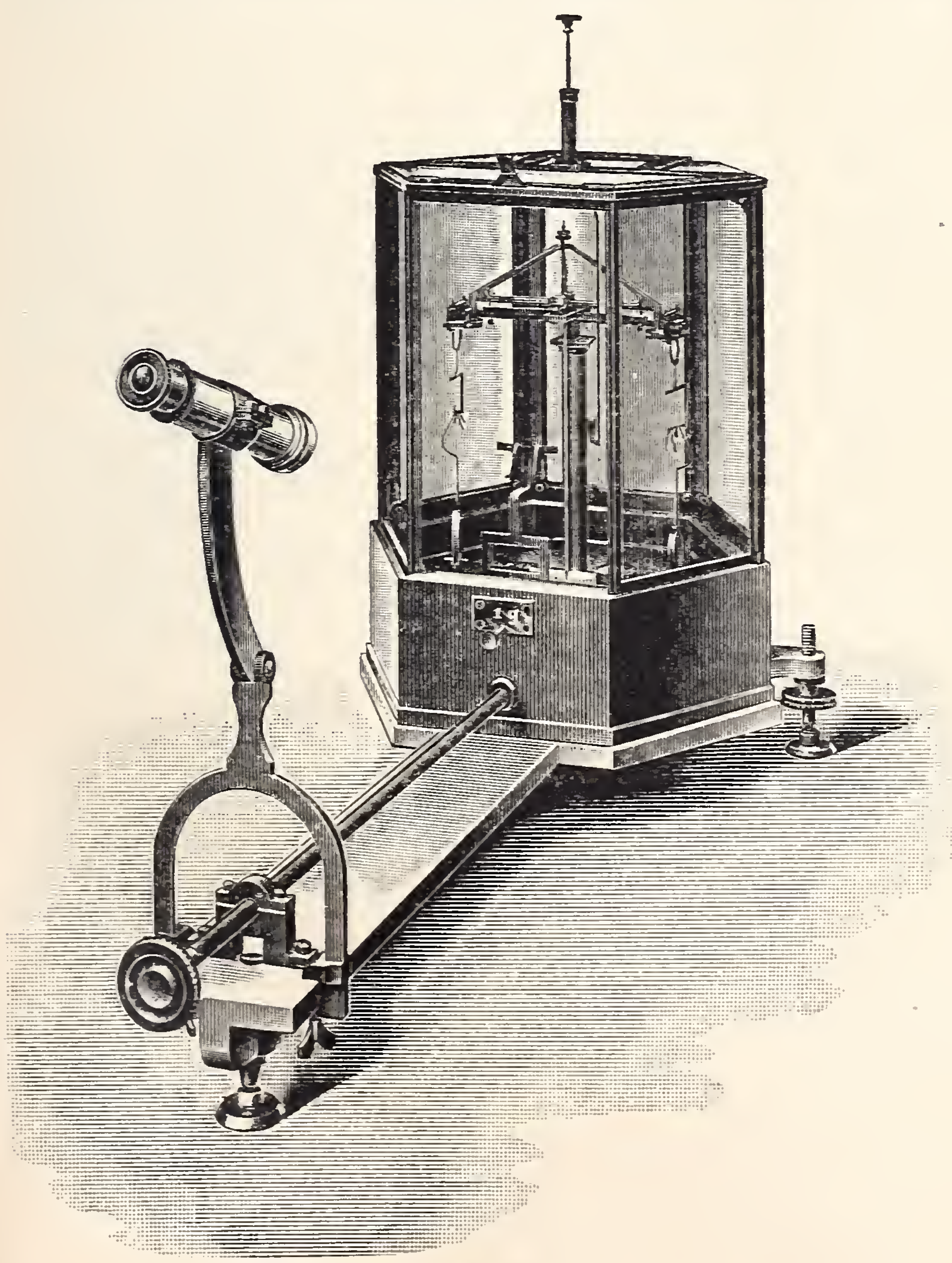


Fig. 10.

A similar balance employed for the comparisons with the prototype is described in No. 1, III of the Wissenschaftliche Abhandlungen, "Ueber den Anschluss des älteren Urgewichts

und der Kopien desselben an das deutsche Prototyp für das Kilogramm" (On the relation of the old standard weights and their copies to the new German prototype of the Kilogramme).

7. **Balance** fitted with apparatus for automatically interchanging and adding weights, made by P. Stückrath, of Friedenau-Berlin, for the determination of masses from 10 to 25 kg.

The beam and suspenders are made of brass, the pan-racks of partinium, the knife-edges of steel and the planes of agate. The degree of sensitiveness is determined automatically by externally worked riders. The arresting devices for the beam, the suspenders and weight supports are raised and lowered by a rod projecting 1 m from the case. The necessary movement is effected by drawing a wedge backwards and forwards. The deflections of the pointer are read by a telescope at a distance of 1 m. The carrier and weight supports are made in the form of a grating so as to render the balance available for extremely fine compound weighing by automatic interchange without the use of plates, which otherwise would double the necessary number of operations.

8. **Milligramme Balance,** made in 1878 by P. Stückrath, of Friedenau-Berlin, for the determination of masses from 0·1 mg to 1 g.

The beam, suspenders and pans are made of aluminium, the planes of agate, and the centre and end-knives are each replaced by a pair of agate points. The sensitiveness is determined by means of two riders, having a difference in weight of 1/20 mg and causing a deflection of 5 to 6 divisions of the scale. The arresting devices of the beam and suspenders are raised and lowered by a rod projecting 40 cm from the balance. The scale is read by means of a telescope. The sensitiveness and addition riders are lifted on and off and the pans together with a portion of the suspenders interchanged by the circular movement of a crank projecting from the case. The rider and pan carrier is movable. Fig. 10 gives a general view of the balance.

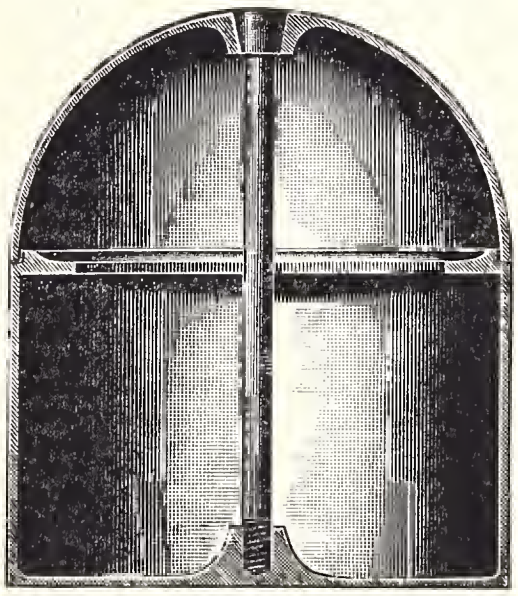


Fig. 11.

9. **Two Stands with Bell Glass** for the preservation of very fine weights, made by P. Stückrath, of Friedenau-Berlin.

The stand is made of wood and carries above an unpierced brass plate to which three ivory blocks are attached by means of brass screws. The weights are placed upon the ivory blocks and protected from dust by the bell glass. See also Mittheilungen der Kaiserlichen Normal-Aichungs-Kommission, 1. Series No. 21, Ueber die Aufbewahrung feinerer Gewichte aus Messing und dergleichen (On the preservation of fine brass and other weights).

10. **Two Air-weights** for determining the variable weight of air by Regnault's method, made in 1886 by B. Pensky (now Sommer & Runge), of Berlin. Both bodies have approximately the same mass and surface while their volumes differ by 300 cmm. One of these bodies is solid and has the form of a stout cylindrical ring, while the other, as shown in Fig. 11, has the form of a hollow shell fitted with internal ribs. Both bodies consist of the best copper and are thickly gilt. They have repeatedly been tested in Berlin by the Imperial Office of Standards and three times by the Bureau International des Poids et Mesures, of Sèvres. Both have proved fairly satisfactory although it has not been possible to entirely eliminate changes in their weights.

11. **Sets of Weights.**

1 Set of weights from 500 to 1 g, made of platinum-iridium, in 1885 and 1889.
1 Set of weights from 1 kg to 1 g, made of aluminium, in 1889, by P. Stückrath, of Berlin-Friedenau.
1 Set of weights from 1 kg to 1 g, made of rock-crystal, in 1875, by Karl Stollnreuther, of Munich.
1 Set of weights from 1 kg to 1 g, made of gilt copper, in 1888 (1 kg) and 1891, by P. Stückrath, of Friedenau-Berlin.
1 Set of weights from 1 kg to 1 mg, made by E. Mentz, of Berlin, in 1898, 1 kg to 1 g being made of nickeled brass, 500 to 10 mg of platinum, 5 to 1 mg of aluminium.
1 Set of weights from 500 to 1 g, made in 1883 by P. Stückrath, of Friedenau-Berlin, of gilt brass.
1 Set of weights from 500 to 0·1 mg, made in 1899 by P. Stückrath, of Friedenau-Berlin, viz. 500 to 10 mg of platinum, 5 to 0·1 mg of aluminium.
1 Set of weights from 20 kg to 1 kg, made in 1875 by P. Stückrath, of Friedenau-Berlin, of gilt brass.

See also the following publications by the Imperial Office of Standard Weights and Measures:—

Metronomischer Beitrag No. 1, Berechnung von Volumen- und Gewichtsbestimmungen mit Rücksicht auf die Schwankungen der Dichtigkeit des Wassers und der Luft von W. Förster, Berlin, Ferd. Dümmler's Verlag (Computation of volumes and weights with regard to the oscillations of the density of water and air, by W. Förster, Berlin, published by Ferd. Dümmler).

Metronomischer Beitrag No. 2, Ueber Veränderlichkeit von Platin-Gewichtsstücken (On the variability of platinum weights, by Dr. L. Loewenherz, Berlin 1875, printed by A. W. Schade).

Mittheilungen 1. Series No. 2, Variability of Weights.
- 1. - - 6, Electrical phenomena observed in weights of rock-crystal and glass.
- 1. - - 24, Weights of yellow metal.
- 2. - - 3, On the after-test of the controlling standards of gold coin weights.
- 2. - - 8, The first recurrent test of the standards of 1883 for controlling commercial cast iron weights.

Zusammenstellung der für eine gleichartige Ausführung der periodisch wiederkehrenden Prüfungen und Berichtigungen der Normale, Waagen und Normalapparate der Aichämter wesentlichen Gesichtspunkte und Vorschriften. Vom 15. Januar 1879. (A review of the aspects and requirements governing the uniform performance of periodically recurring examinations and corrections of standards, balances and standard appliances for testing stations, 15th of January 1879.) Published by W. Moeser, Berlin.

Die Herstellung und die wiederkehrende Prüfung der Hauptnormale und Kontrolnormale (The production and periodical examination of the original and controlling standards), 1886. Published by W. Moeser, Berlin.

12. Prototype for Alcoholometers divided in percentages by volume. This set consists of 7 spindles made by J. C. Greiner sen. & Sohn, of Berlin. The divisions advance in tenths of percentage and admit of thousandths being estimated. The standard reads percentages of Tralles's scale of volumes and is calibrated within 0·001 per cent for a normal temperature of $12^4/_9$° R. ($15^5/_9$° C.).

13. Prototype for Alcoholometers divided in percentages by weight. This set consists of 6 spindles made by J. C. Greiner sen. & Sohn, of Berlin. It is a copy of the fundamental standard and, like this, reads to 0·001 per cent at the legal normal temperature of 15° C.

14. Standard Hydrometer. This set, made of Jena glass by J. C. Greiner, of Berlin, consists of 20 spindles and embraces a range of density of 0·62 to 2·00. Each spindle comprises an interval of 0·07 of the density and is divided into half units of the third decimal. The set is primarily intended for testing mineral oil hydrometers and sulphuric acidmeters, but is also available as a standard for lyes and other fluids. The normal temperature is 15° C., and the maximum density of water is taken as the unit of density.

15. Two Hydrostatic Balance Floats. These floats are made of Jena glass and have a volume of about 200 ccm and a mass of 300 and 500 g, their densities being accordingly 1·5 and 2·5 respectively. The floats are employed for standardizing hydrometers at a constant temperature, whereas the thermal expansion of fluids is measured by means of smaller floats of 50 ccm readily acquiring the temperature of the surrounding medium.

16. Standard Saccharimeter graduated in percentages by weight. This set consists of 5 spindles, each of which embraces a range of 20 per cent and reads to 0·1 per cent. The instruments have been made of Jena glass by J. C. Greiner sen. & Sohn, of Berlin. Their errors have been calibrated to 0·001 per cent, both at the legal German standard temperature of 20° C. and that of 15° C.

See also Mittheilungen, 2. Series No. 6, Vorschriften über Fehlergrenzen, Prüfung und Beglaubigung von Saccharimetern (Directions respecting the admissible limits of errors and the examination and certification of saccharimeters).

17. Milk Hydrometers. A spindle made of Jena glass by J. C. Greiner sen. & Sohn, of Berlin, embracing a range of densities from 1·0194 to 1·0406 and reading to two units of the fourth decimal.

The instrument reads, at the standard temperature of 15° C., densities referred to that of water at 15° C. taken as the unit, and serves for testing official lactometers.

18. Hydrometer for Beer. This set consists of two spindles of Jena glass embracing ranges from 1·0097 to 1·0333 and from 1·0327 to 1·0563, and reading to units of the fourth decimal. The standard temperature is 17·5° C., and the readings refer to the density of water at the same temperature taken as the unit. The spindles are accurately tested within units of the fifth decimal.

The following are among the works and tables published by the Imperial Office of Standard Weights and Measures relating to alcoholometry and hydrometry:—

Metronomischer Beitrag No. 6, Kapillaritätsuntersuchungen von Dr. B. Weinstein, Berlin 1889, Verlag von Julius Springer (Investigations on capillarity by Dr. B. Weinstein, Berlin 1889, published by Julius Springer).

Metronomischer Beitrag No. 7, Ueber die Bestimmung von Aräometern von Dr. B. Weinstein, Berlin 1890, Verlag von Julius Springer (On the adjustment of hydrometers by Dr. B. Weinstein, Berlin 1890, published by Julius Springer).

Mittheilungen 1. Series No. 8, Beziehungen zwischen den Angaben eines Volumen- und eines Gewichtsalkoholometers (Relations between alcoholometer readings by volume and by weight).

- 1. - - 11, Kapillaritätsuntersuchungen und ihre Verwerthung bei der Bestimmung der alkoholometrischen Normale (Researches on capillarity and their application in the adjustment of alcoholometric standards).
- 1. - - 13, Ueber die Bestimmung von Aräometern mit besonderer Anwendung auf die Feststellung der deutschen Normale für Alkoholometer (On the adjustment of hydrometers with special regard to the establishment of the German alcoholometric standards).
- 1. - - 13, Ueber die amtliche Beglaubigung von Aräometern (On the official certification of hydrometers).
- 1. - - 22, Beziehungen zwischen den Angaben eines Gewichts- und eines Volumenalkoholometers, sowie zwischen wahren Volumenprozenten und wahren Gewichtsprozenten (The relations between alcoholometric readings by weight and by volume, also between the true percentage readings by volume and by weight).
- 1. - - 7, 8, 17, Vorschriften über Fehlergrenzen, Prüfung und Beglaubigung von Alkoholometern und Aräometern (Directions respecting the admissible limits of error in the examination and certification of alcoholometers and hydrometers).

Tafel zur Ermittelung des Alkoholgehaltes von Spiritusmischungen. Amtliche Ausgabe. 1888. Julius Springer, Berlin. (Table for determining the proportion of alcohol contained in alcoholic mixtures. Official edition. 1888. Published by Julius Springer, Berlin.)

Tafel zur Ermittelung des Alkoholgehaltes von Spiritusmischungen. Ergänzungstafel für hochprozentige Spiritusmischungen. 1888. Julius Springer, Berlin. (Table for determining the proportion of alcohol contained in alcoholic mixtures. Supplementary table for high percentage spirit mixtures. 1888. Julius Springer, Berlin.)

Tafel zur Ermittelung des Alkoholgehaltes von Spiritusmischungen. Ausgabe für Gewichtsalkoholometer. 1888. Julius Springer, Berlin. (Table for determining the proportion of alcohol contained in alcoholic mixtures. Edition for alcoholometry by weight. 1888. Julius Springer, Berlin.)

Tafel zur Ermittelung der Stärke von denaturirtem Branntwein. Amtliche Ausgabe. 1898. Julius Springer, Berlin. (Table for determining the strength of methylated spirits of wine. Official edition. 1898. Julius Springer, Berlin.)

Tafel zur Ermittelung der Dichte von amerikanischem Petroleum und dessen Produkten mittels des Thermo-Aräometers. 1892. Julius Springer, Berlin. (Table for determining the density of American petroleum by means of a thermo-alcoholometer. 1892. Julius Springer, Berlin.)

Tafel zur Ermittelung der Dichte von Braunkohlentheer-Destillaten mittels des Thermo-Aräometers. 1892. Julius Springer, Berlin. (Table for determining the density of coal-tar distillates by means of a thermo-hydrometer. 1892. Julius Springer, Berlin.)

Zusatztafel für russisches Petroleum und dessen Produkte zu der Tafel zur Ermittelung der Dichte von amerikanischem Petroleum und dessen Produkten. 1893. Julius Springer, Berlin. (Table for Russian petroleum and its products; supplement to the table for determining the density of American petroleum and its products. 1893. Julius Springer, Berlin.)

Anleitung zur steueramtlichen Ermittelung der Dichte und des Gewichtes von amerikanischem und russischem Petroleum mittels des Thermo-Aräometers. 1894. Julius Springer, Berlin. (Directions for determining, for the purposes of excise, the density and weight of American and Russian petroleum by means of thermo-hydrometers. 1894. Julius Springer, Berlin.)

Zusatztafel für mineralische Leuchtöle zu der Anleitung zur steueramtlichen Ermittelung der Dichte und des Gewichtes von amerikanischem und russischem Petroleum mittels des Thermo-Aräometers. 1894. Julius Springer, Berlin. (Supplementary table to directions for

determining, for the purposes of excise, the density and weight of American and Russian petroleum by means of the thermo-hydrometer. 1894. Julius Springer, Berlin.)

Tafel zur zollamtlichen Abfertigung von Verschnitt-Weinen und -Mosten. 1894. Julius Springer, Berlin. (Table for the customs examination of diluted wines and musts. 1894. Julius Springer, Berlin.)

19. **Two Thermometers divided into 0·01° C.,** made of Jena glass by R. Fuess, of Steglitz, near Berlin. They are used in the process of standardizing hydrometers, where the measurement of small oscillations of temperature is required. The range of the graduations is such as to cause the hydrometrically important interval of 15 to 20° C. to occupy the intermediate portion of the scale. The thermometers are provided with a short freezing point scale so as to periodically ascertain oscillations of the freezing point. These thermometers possess over the ordinary thermometers divided into 0·1° the advantage of affording more accurate readings, which is particularly desirable with cloudy and semi-opaque liquids, and have proved most satisfactory in this respect.

20. **Apparatus for customs determination of the percentage of alcohol in brandies, liqueurs, essences and fruit-juices,** consisting of:—

1 hydrometer jar of 100 ccm capacity;
2 alcoholometers, for 0 to 30 per cent, and 29 to 57 per cent;
1 burette of 300 ccm with stand and holders.

21. **Apparatus for customs determination of the percentage of alcohol, sugar and extracts contained in wines and musts,** consisting of:—

2 thermo-alcoholometers of 0 to 12 per cent and 10 to 22 per cent respectively;
2 thermo-saccharimeters of 0 to 16 and 15 to 31 per cent respectively; all accessories and 1 one-quantity pipette of 50 ccm;
1 burette of 50 ccm divided into $^1/_{10}$ ccm, 2 burettes of 25 ccm divided into $^1/_{10}$ ccm, 1 graduated glass measure of 100 ccm divided into $^1/_1$ ccm.

22. **Chemical Measuring Appliances.** The exhibits comprise a selection of the most generally used chemical measuring glass appliances, e. g. burettes, pipettes, graduated cylinders, flasks, &c., such as are admitted in Germany to official tests and certification. These tests are made in accordance with the decrees of the International Congress of Applied Chemistry, held at Paris in 1896, and are calculated to ensure to the analyst a certain degree of accuracy, inasmuch as certified appliances are required to satisfy certain conditions as to construction and accuracy.

The computation of the total and subdivisional capacities is based upon the litre, i. e., the space occupied by 1 kg of water at its maximum density.

According to existing requirements the appliances are certified for temperatures of 15°, 17·5° or 20° C., for measurement by pouring in or out. The number of glass appliances thus certified in Germany exceeds 80,000 within the last 5 years.

Some of the appliances serve for the examination of sugar, others for ascertaining the viscosity of oils, and yet others for titration, analysis of fusel, &c.

Official publications relating to chemical measuring appliances will be found in Mittheilungen 1. Series No. 22; 2. Series Nos. 4, 5, 6 of the Imperial Office of Standard Weights and Measures.

23. **Siemens's Alcoholometer** for determining quantities of spirit and alcohol in distilleries.

The quantity of spirit is measured by a drum fitted with three measuring chambers surrounding a cylinder. The spirit flows through the latter into that measuring chamber which happens to occupy the lowest position so as to fill it, after which it passes into the second chamber at its side. This causes the drum to turn, whereby the first chamber is made to empty itself, while the second chamber takes its place. The movement of the drum is recorded by a counter and dial.

The strength of the spirit is measured previous to its entrance into the measuring drum. For this purpose it is passed into a tank through a specially arranged system of pipes where it is at the same time automatically mixed. The tank contains a float attached to the free end of a spring which is depressed more or less according to the strength of the spirit and the corresponding buoyancy of the float. The spring actuates a lever which indicates on a plane curve the position of the float and, accordingly, the strength of the spirit.

The strength is registered by means of a trifoliated cam attached to the drum shaft, upon the rim of which glides a wheel attached to one arm of a crank-lever, whilst the other arm with its foliated curve describes a reciprocating movement, which, however, by contact with the cam-lever, is limited in such a way as to cause the curve to describe an angular movement corresponding to the strength of the spirit. The crank-lever is coupled to the "alcohol wheel" by a spherical ratchet in such a manner as to constrain the wheel to follow only that movement of the curve which is directed to the left. The wheel turns accordingly in one direction only, the angle of rotation being proportional to the

strength of the spirit. Its movement is transmitted to a counting dial which indicates the quantity of alcohol contained in the spirit.

24. Siemens's Sampler. This apparatus registers the quantity of liquid passed through it and at the same time abstracts a sample of the latter. The drum of this apparatus is similar to that of the alcoholometer, but, in addition, it is fitted with three sample takers. From these the samples flow, at each discharge of the measuring chambers, into a tank where they are allowed to accumulate. From the strength of these accumulated samples, as ascertained by means of an alcoholometer, and the registered quantity of spirit it is easy to calculate the quantity of alcohol contained in the spirit.

German distilleries are provided with 600 alcoholometers and 400 samplers, all made by Messrs. Siemens Brothers, of Charlottenburg, and certified by the Imperial Office of Standard Weights and Measures. This Office is also responsible for the supreme technical supervision of the working of these appliances. This supervision is effected partly by its own officers and partly by excise officers trained at the Office of Standard Weights and Measures.

Publications:—

Anleitung zur steueramtlichen Ermittelung des Alkoholgehaltes im Branntwein. Amtliche Ausgabe (2. vervollständigte Auflage) 1890. Julius Springer, Berlin. (Directions for the determination, for the purposes of excise, of the percentage of alcohol in spirits. Official issue (2nd enlarged edition). 1890, published by Julius Springer, Berlin.

Zusatztafeln für geringhaltige Branntweine zu der Anleitung zur steueramtlichen Ermittelung des Alkoholgehaltes im Branntwein. Amtliche Ausgabe. 1893. Julius Springer, Berlin. (Tables for under-proof spirits, supplementary to the Directions for determining, for excise purposes, the percentage of alcohol in spirits. Official issue. 1893. Julius Springer, Berlin.)

25. Standardizable Grain-testers, for ascertaining the quality of grain, made in 1899 by Messrs. Sommer & Runge. These appliances are made in two sizes, viz. for 1 l and 1/4 l. Those exhibited are used by the Imperial Office of Standard Weights and Measures for standardizing purposes. They are accordingly made stronger than those in ordinary use, so as to obviate deformations as far as possible.

Each apparatus consists of:—

1. a balance provided with the requisite weights;
2. a measure slotted at the top;
3. a short cylinder, known as the fore-runner;
4. a scraping knife;
5. a filling tube which can be firmly placed upon the measure;
6. a wooden plate to fix the measure.

The measure is fixed on the wooden plate, the knife is passed into the slot, the fore-runner is then placed upon the measure and the filling tube firmly fitted to the measure. The grain is carefully poured in and levelled off with some straight article. The withdrawal of the knife will cause the grain together with the fore-runner to fall into the measure. The knife is then again passed through the slot, the result being that any grains which happen to be clamped between the knife and the wall of the measure will be cut through. The superfluous grain is then poured out and the filling tube removed. The measure with its contents is weighed, and the weight of the measure and fore-runner being balanced by a counter weight, this operation shows at once the weight of 1 l and 1/4 l respectively.

Official publications by the Imperial Office of Standards relating to the grain-tester will be found in the

Mittheilungen, 1. Series Nos. 14, 16, 18, 21 and 22,
" 2. " " 7 and 8,

and in the following publications:—

Ueber den durch Erlass vom 14. Mai 1891 zur Aichung zugelassenen Apparat zur Qualitätsbestimmung des Getreides (Getreideprober); herausgegeben von der Kaiserlichen Normal-Aichungs-Kommission, Berlin, Julius Springer, 1891. (On an apparatus for testing the quality of grain (grain-tester) accepted as a standard apparatus by a decree dated 14th of May 1891, issued by the Imperial Office of Standards, Berlin, published by Julius Springer.)

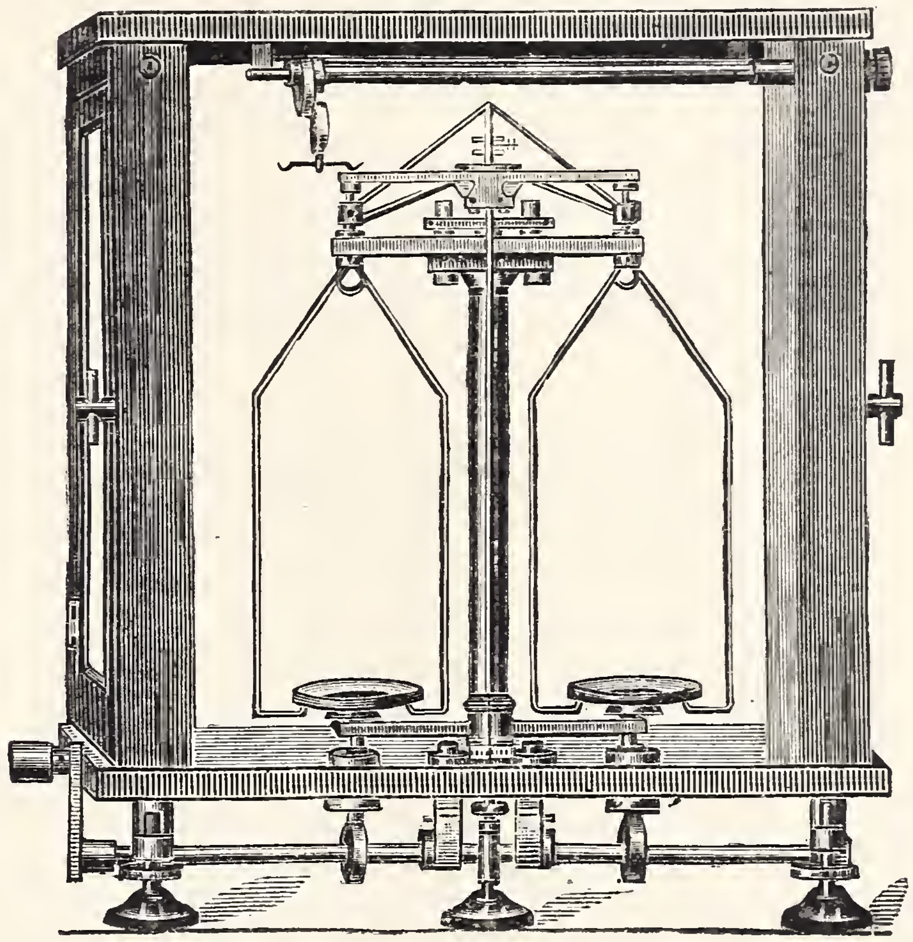
Tafel zur Vergleichung der Angaben des aichfähigen Getreideprobers mit anderen beim Getreidehandel üblichen Qualitätsbestimmungen. 1899. Julius Springer, Berlin. (Table for comparing the indications of the standardizable grain-tester with other commercial methods of ascertaining the quality of grain. 1899. Julius Springer, Berlin.)

2. Max Bekel, Hamburg, 3 Rossberg.

Manufacturer of Precision Balances.

Established 1855.

Holder of awards for excellence of workmanship in Precision Balances.



Physical, Chemical and Technical Balances. Assay Balances for precious metals.

Specific Gravity Balances.

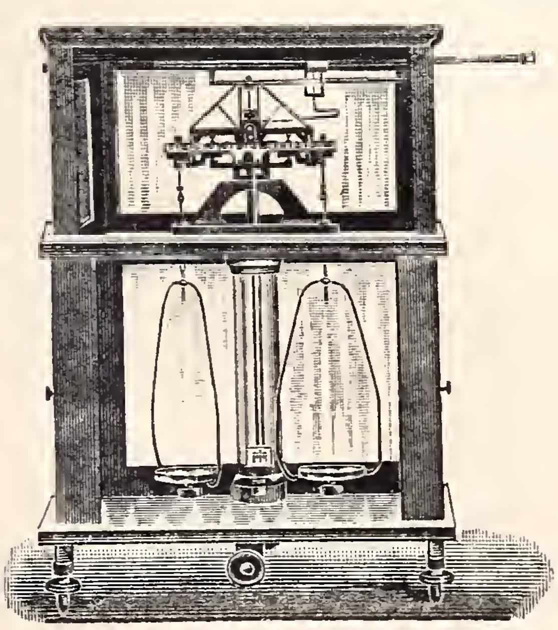
Balances with optical reading appliances.

Balances fitted with mechanism for charging with closed case. Balances of two degrees of sensitiveness for analytical and technical weighing respectively. Balances fitted with secondary differential balance (D.R.G.M.).

Weights of pebble and gilt metals.

Detailed Catalogues on application.

Telegraphic address:—"Bekel Hamburg."



3. J. & A. Bosch, Strassburg, Alsace.

Philosophical Instrument Makers.

(See also Section III a.)

Analytical Balance for a maximum charge of 200 g, in double casing. The addition of 1 mg produces a deflection of 10°. The beam and mechanical parts are encased during the weighing operation; changes of temperature and the heat of the body produce, therefore, no perceptible effect. The balance is very constant. Means for adjusting the axes are absent, experience having shown adjustable axes to be a constant source of error. The balance is fitted, to order, with agate knife-edges.

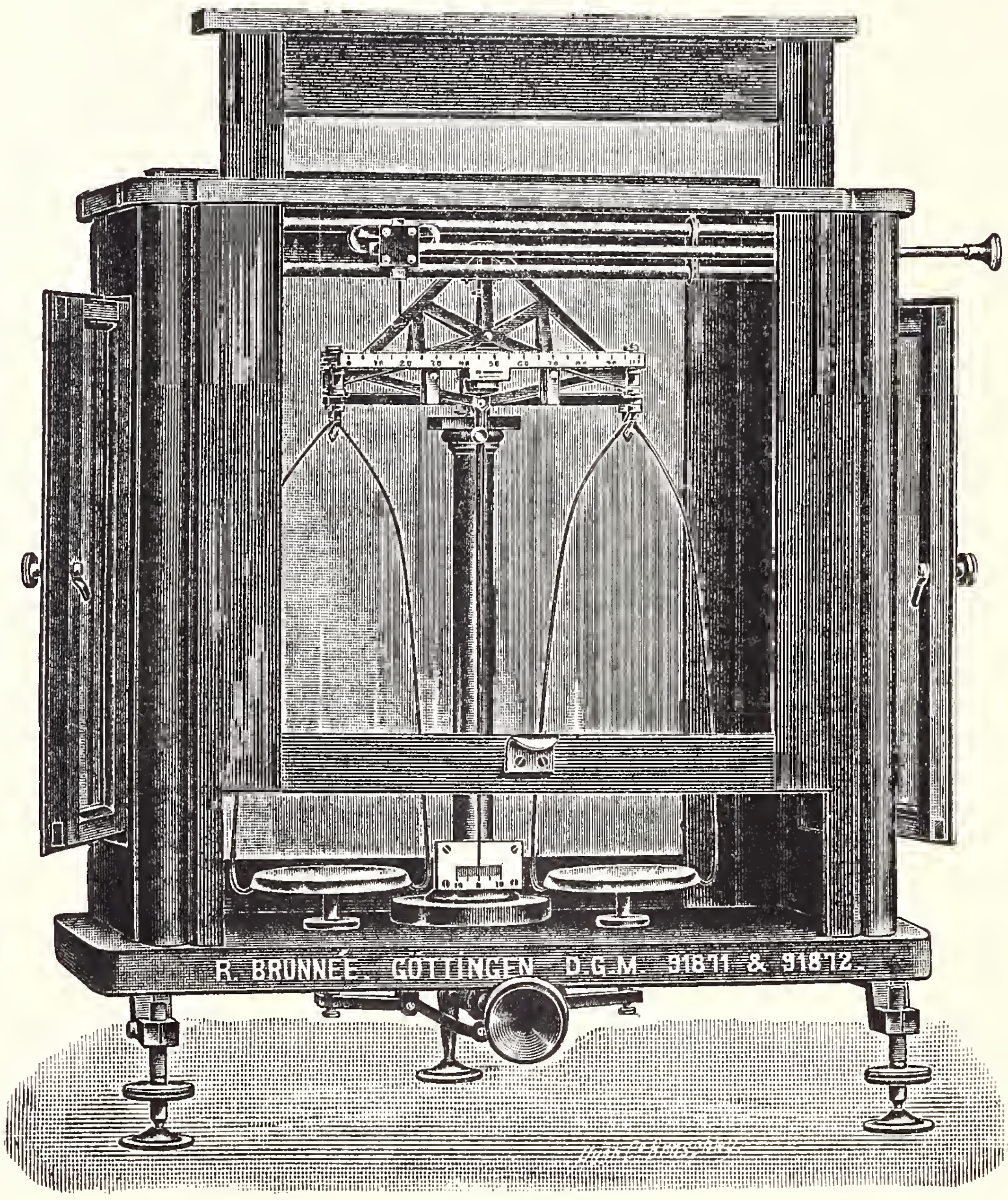
4. R. Brunnée (late Voigt & Hochgesang), Göttingen.

Mechanician.

(See also Section Vg.)

1. **Analytical Balance for a charge of 500 g.**

2. **Analytical Balance for a charge of 200 g.** These balances are of an entirely new construction. (Reg. in Germ. D.R.G.M. No. 91,871, 91,872; American patent No. 634,495.) The beam is high and stiff; the stiffening struts are spread outwards and form a roof-shaped skeleton joined at the centre by a suspension block. The whole middle part of the beam is clamped by the pointer carrier. The beam, though light in itself, possesses a very high carrying power; it is also little affected by changes of temperature, being entirely made of uniformly hard-rolled sheet aluminium or argentan and consisting, apart from the pointer carrier, of only two parts firmly joined together by a few fine rivets. The load is uniformly distributed over the entire length of the central axis.



The balances are fitted with an entirely new device for lifting the beam off the agate pans. (Reg. in Germ. No. 91,871.) The small stems serving to lift off the suspensions are rigidly attached to the beam, so as to ensure absolutely accurate replacement of the knife-edges even if it were possible for the beam to be gripped in an inclined position.

The riders can be shifted by an extremely smooth movement, which cannot in any way be disturbed.

This balance was shown for the first time at the Exhibition of Novelties connected with the 70th Meeting of the German Naturalists and Physicians held at Düsseldorf, and was awarded a diploma and a special certificate of excellence.

5. Paul Bunge, Hamburg, 13 Ottostr.

Mechanical Institute.

Established 1866.

Speciality: Physical and Chemical Balances and Weights.

Gold Medals and Diplomas:
Vienna 1873, Hamburg 1876, Brussels 1888, Hamburg 1889, Chicago 1893, Brussels 1897.

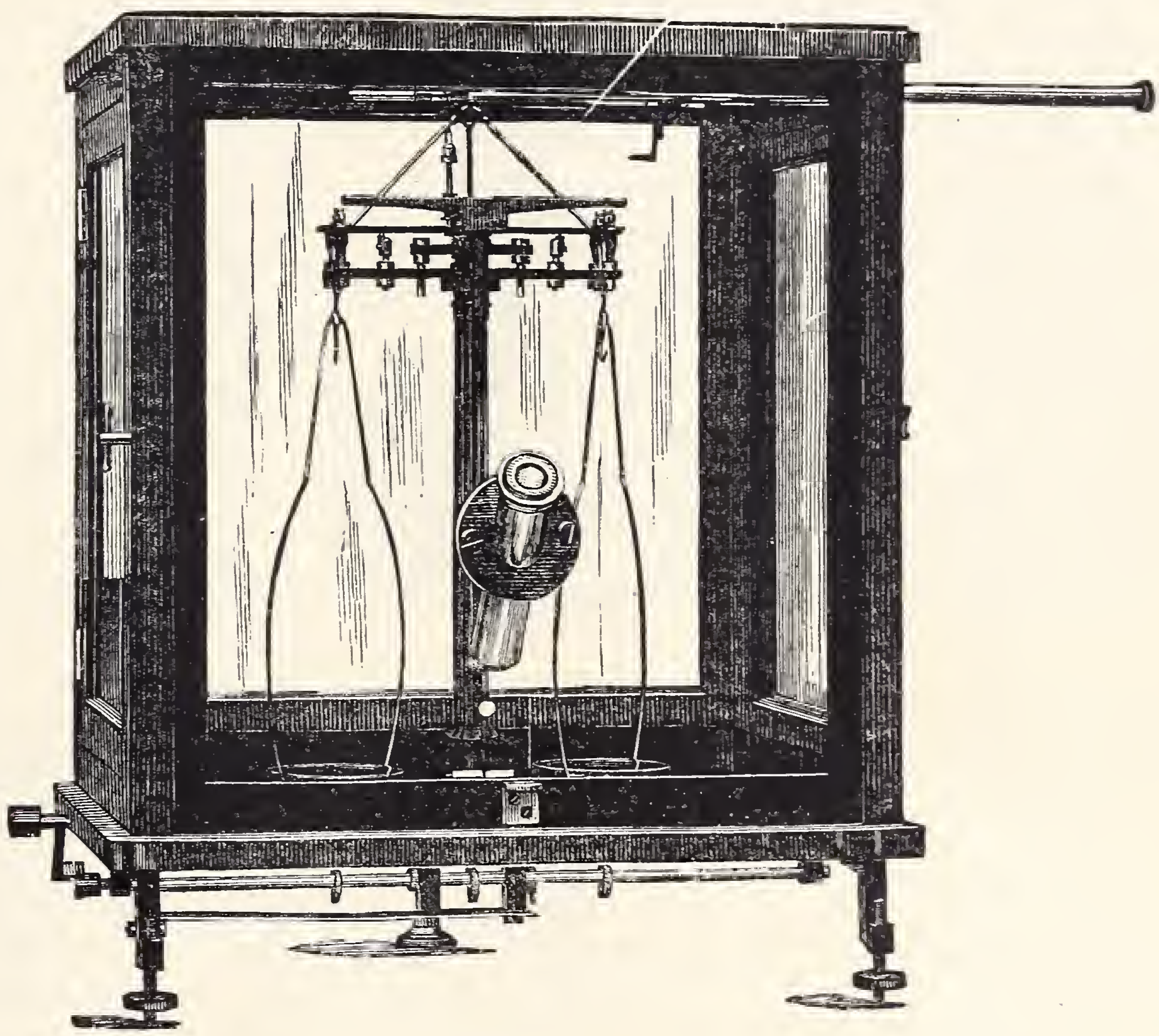


Fig. 1.

1. Physical and Analytical Balance for a maximum charge of 200 g. This balance is available for rapid working within $^1/_{10}$ mg, or for a maximum degree of exactness within $^1/_{200}$ mg, which can be read direct as divisions of a scale. The axis and bearings and all supporting parts of the beam, stirrups and pans are made of agate. The beam is 0·13 m long and made of the finest argentan and, though very light in itself, is extremely rigid. The pans are of pebble. Fig. 1.

2. Analytical Balance for a maximum charge of 200 g with patent device by which the approximate weight of the charge can be read as soon as placed upon the scale-pan. Fig. 2.
Below the right hand end axis of the beam is situated a small round spindle, from which the hook of a lever balance can be suspended, when it is required to throw it into play. The scale of this lever-balance, which is very large and distinct, is situated behind the column so as not in the least to interfere with the accessibility of the balance case. This arrangement is particularly useful for frequent weighing of bodies of varying densities.

3. Physical and Analytical Balance for a maximum charge of 200 g, with an arrangement for interchanging the pans without opening the case. A detailed description will be found in the firm's principal Catalogue of Balances No. 1 g, p. 21. Fig. 3.

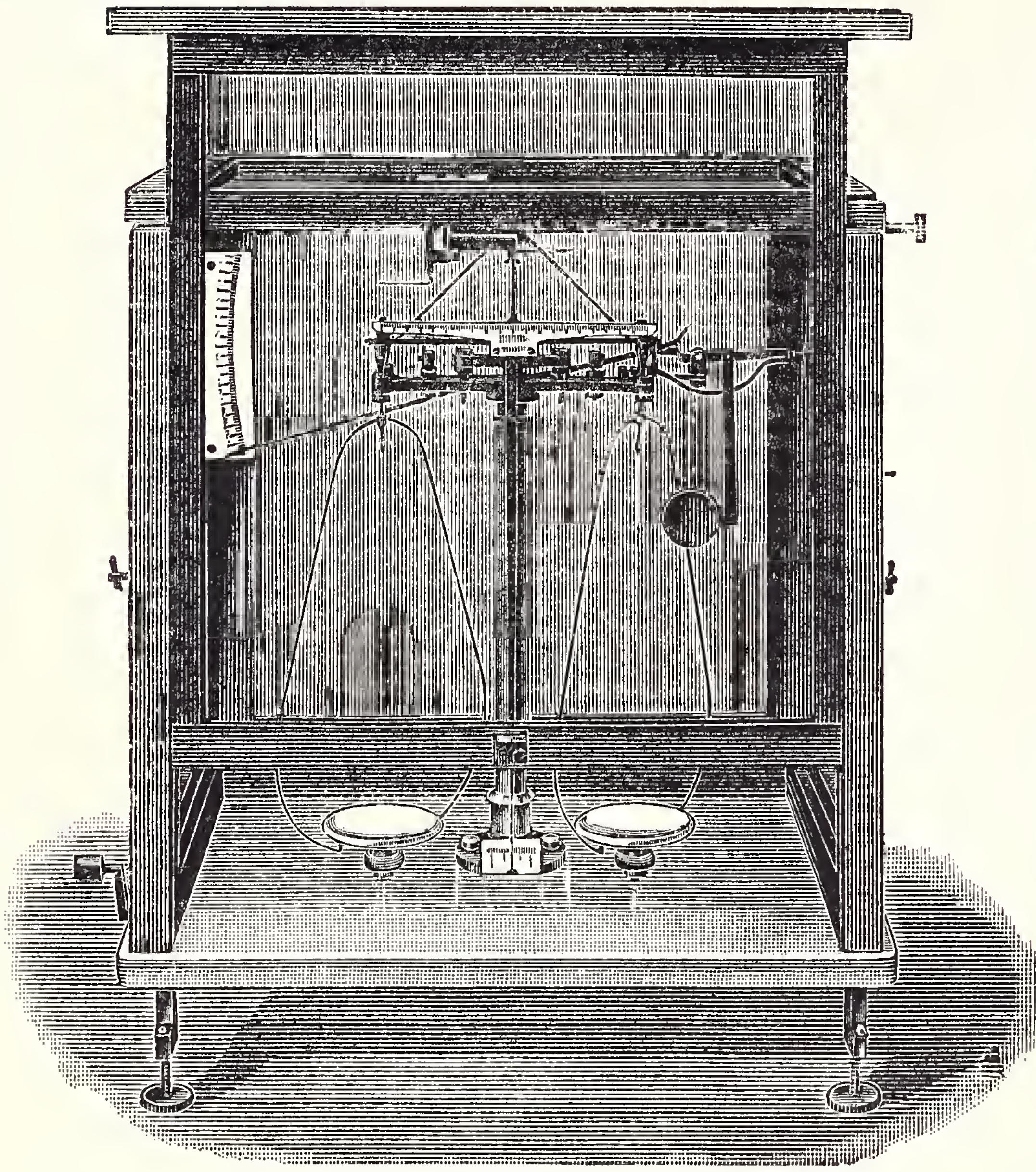


Fig. 2.

With this balance double weighing can be carried out in almost the same time as single weighing in other balances, since, after setting the balance up and noting the ratio of the beam, it is not necessary to determine the zero point; for a slight displacement of the zero point, as well as any deviation in the beam, are eliminated by the final mean of two readings. This form of balance is well-nigh indispensable for absolute weighing.

4. Rapid Precision Balance for a maximum charge of 200 g, with two superposed scales read by a lens-mirror. The beam is of gilt gunmetal. Fig. 4.

The balance swings very rapidly, and $^1/_{10}$ mg are read directly with the aid of a lens-mirror, i. e., an achromatic objective having a silvered back, which magnifies, without reflections or distortion, the whole of a milk-glass scale 20 mm long and divided into $^1/_5$ mm and mounted above the ivory scale.

Weights in terms of milligrammes are read from the ivory scale, a glance on the glass scale as seen in the mirror being only required in order to estimate the tenths of a milligramme with certainty.

The eyes are thereby not strained in the least since the optical reading is only taken at the last moment; moreover, the magnified scale is seen with both eyes. The use of both scales entails, in fact, no inconveniences of any kind.

5. Physical and Analytical Balance for a load of 500 g, with reading collimator and an arrangement for mechanically charging and discharging the weight pan without opening the case.

The following are the advantages which this balance possesses as an instrument for research and chemical analysis and which are not shared by other balances:—

The weights are placed accurately centrally upon the pan without friction, or the risk of shock or accidental dropping, by purely mechanical means, first by sliding the carriers, having the value of the respective weights marked upon them, from right to left as

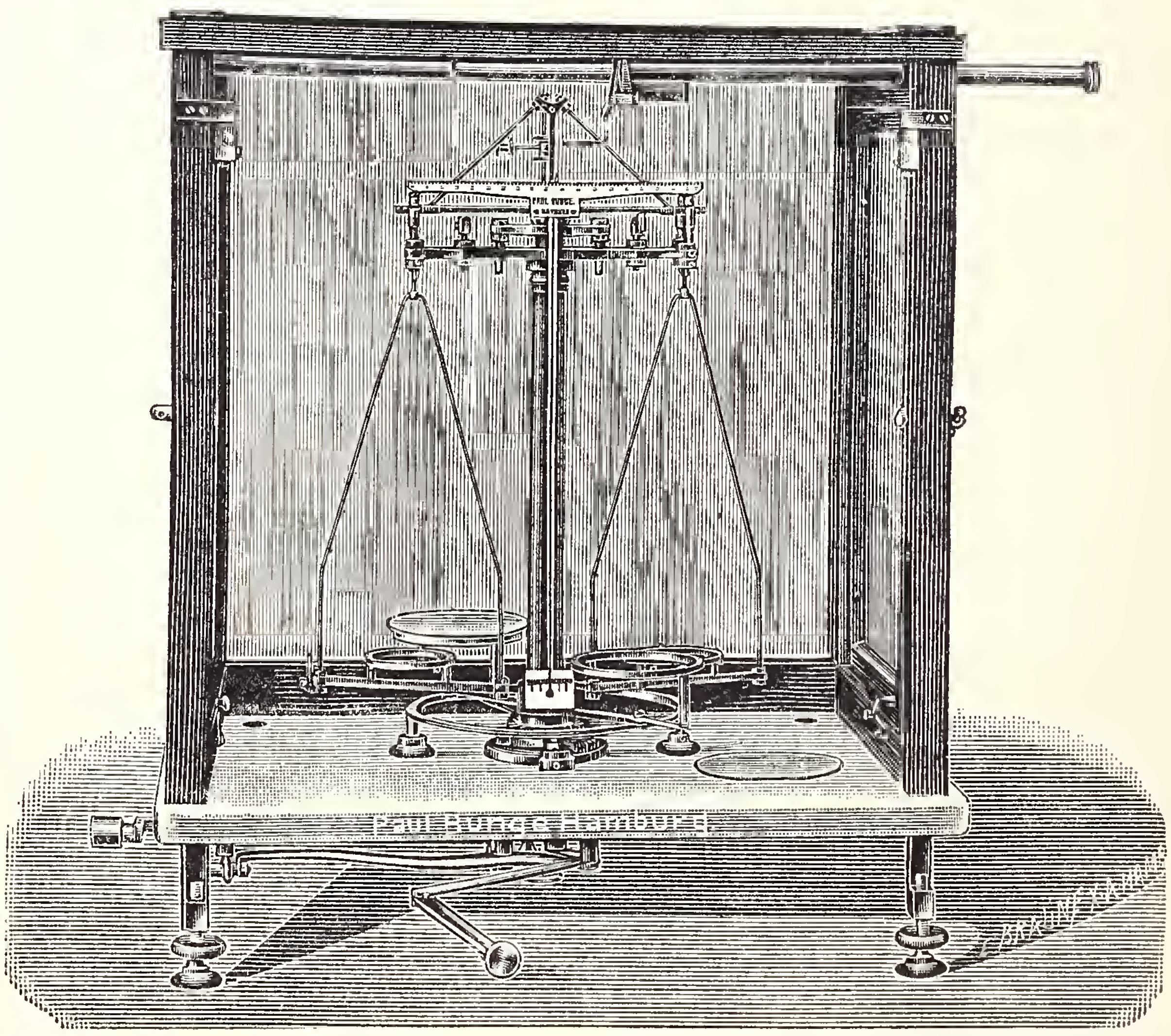


Fig. 3.

far as the stop will allow; then by turning a crank from one distinctly marked position into another, and thirdly in moving the carriers back as far as the stop on the right. The reversed process is adopted for lifting the weights off.

With other balances in which the index scale embraces 1 mg only, repeated arrests and releases are required in order to find from the position of the rider the third and fourth places of decimals, whereas in this balance, in which the pointer is only deflected one degree per milligramme, and where, therefore, the entire scale encompasses a centigramme, the third place of decimals can be determined by the first swing, and after one arrest and release the fourth place of decimals may be read and the fifth estimated with the aid of the collimator. By combining the low position of the centre of gravity with very exact readings the rapidity of the oscillations has been reduced as compared with that of a similarly sensitive balance in the proportion of $1:\sqrt{10}$ and yet vouchsafes a ten times greater degree of constancy in the sensitiveness of the balance with changing charges. The beam is made of the finest argentan. The axes and bearings as well as the supporting parts of the beam, stirrups and pans are made of agate. The beam is 0·17 m long.

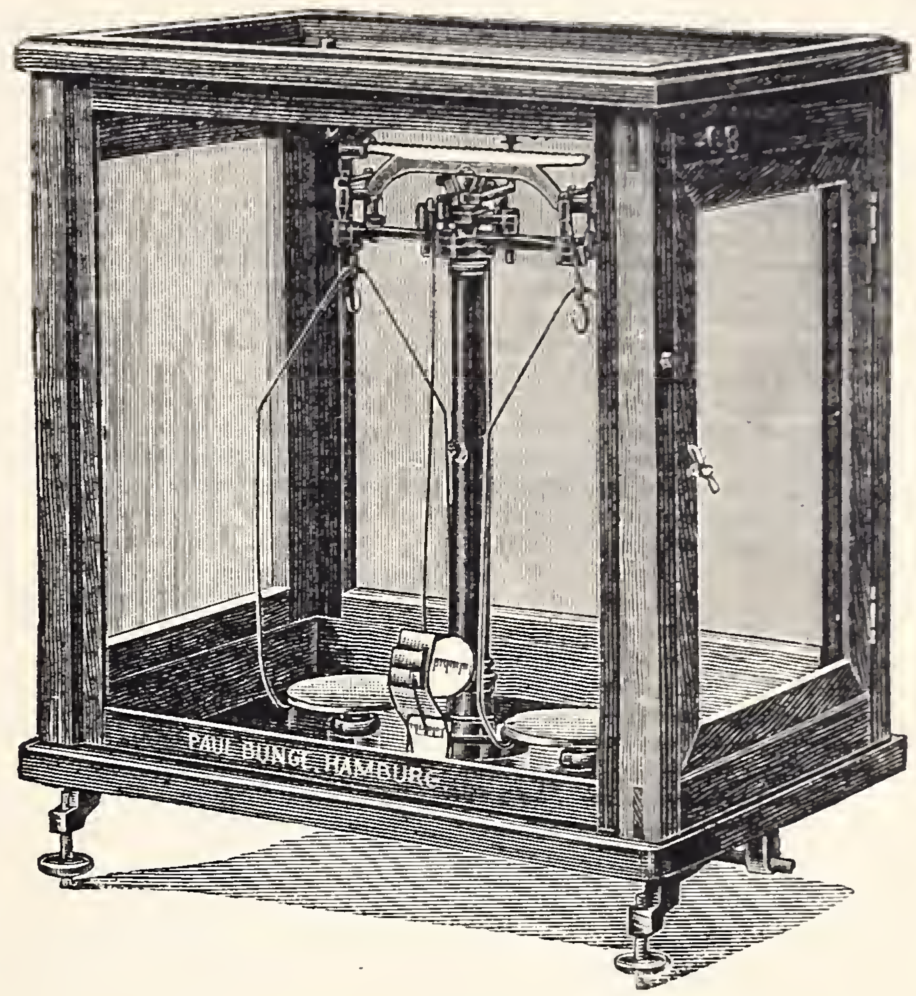


Fig. 4.

6. **Physical Balance for a maximum charge of 1 kg,** for adjusting and comparing standard weights. (Property of the Bureau International des poids et mesures, at Sèvres near Paris.)

This balance is adapted for working at a distance of 5 m so as to obviate the influence of the heat of the body upon the accuracy of the balance.

6. Gottl. Kern & Sohn, Ebingen (Würtemberg).

Makers of Precision Balances and Weights.

1. **Precision Balance** for technical purposes, to carry a charge of 10 kg, sensitive to $^1/_{100000}$ of the charge, with lever for lifting beam and scale-pans, the beam lifting off its bearings by means of supporting arms. The whole balance is mounted upon a box.

2. **Precision Balance,** to carry 500 g, sensitive to $^1/_{100000}$ of the charge, fitted with lever for lifting beam and scale-pans, mounted upon box fitted with levelling-screws, with beam supporting arms.

3. **Precision Balance,** to carry 200 g, sensitive to $^1/_{50000}$ of the charge, fitted with lever for lifting beam and pans, without beam supporting arms, mounted on box.

4. **Assay Balance,** to carry 5 g, sensitive to $^1/_{10}$ mg, with platinum pans, encased in glass.

5. **Precision Balance,** to carry 3 kg, sensitive to $^1/_{20000}$ of the charge, mounted on brass column, with lifting lever.

6. **Dispensing Balance** for druggists, Dr. Mohr's pattern, mounted on a brass column with urn, the beam swinging in front of the column, to carry 1 kg, sensitive to $^1/_{20000}$ of the charge.

7. **Dispensing Balance** for druggists, mounted on brass column with angle bracket, the beam turning in the centre of the column, to carry 500 g, sensitive to $^1/_{20000}$ of the charge.

8. **Retailing Balance** mounted on obelisk-shaped iron stand of latest construction, to carry 3 kg, sensitive to $^1/_{20000}$ of the charge.

9. **Set of Druggist's Hand-scales.**

10. **Set of Gramme Weights** for chemists, apothecaries and dealers.

7. F. Sartorius, Göttingen.

Philosophical Instrument Maker. Speciality: Analytical Balances and Weights.

1. **Short Beam Analytical Balance** with aluminium beam, in mahogany case, with balanced front rider-slide, mounted on a base of black plate glass. All metal parts are platinized. The balance is adapted for a charge of 5 g and is sensitive to 0·02 mg.

2. **Short Beam Analytical Balance** with aluminium beam, for a charge of 100 g and sensitive to 0·05 mg, fitted in an elegant brass bronze case and mounted on a base of black plate glass.

3. **Short Beam Analytical Balance** with aluminium beam, for a charge of 200 g and sensitive to 0·1 mg, fitted in a hexagonal metal case and mounted on black plate glass.

4. **Short Beam Analytical Balance** with aluminium beam, for a charge of 1,000 g and sensitive to 0·15 mg, in a finely polished mahogany case with balanced front rider-slide and mounted on black plate glass.

5. **Short Beam Analytical Balance** with a triangular beam of gilt phosphor-bronze, for a charge of 500 g and sensitive to 0·1 mg, in a polished mahogany case with balanced front rider-slide, mounted on black plate glass and fitted with an arresting arc.

6. **Short Beam Analytical Balance** with rectilinear beam of phosphor-bronze and brass column, for a charge of 200 g and sensitive to 0·1 mg, fitted in mahogany case and mounted on black plate glass.

7. **Short Beam Analytical Balance** with rectilinear beam of phosphor-bronze and green-bronzed column, for a charge of 200 g and sensitive to 0·1 mg.

8. **Short Beam Analytical Balance** with pierced triangular beam, fitted with means for measuring the degree of sensitiveness, encased in a walnut wood-frame and mounted on a walnut sole-plate. This balance is capable of carrying 10,000 g and is sensitive to 2 mg.

9. **Bi-axial Specific Gravity Balance** for fluids, with steel application points.

10. **Bi-axial Specific Gravity Balance** for fluids and solids, with steel application points.

11. **Precision Balance** with beam and pan arresters, for a charge of 2 kg, nickeled.

12. **Precision Balance** with beam and pan arresters, for a charge of 1 kg, lacquered.

13. **Precision Balance** with beam and pan arresters, for a charge of 200 g, nickeled.

14. **Precision Balance** with beam and pan arresters, for a charge of 50 g, nickeled.

15. **Analytical Weights,** set of 50 g, gilt.

16. **Analytical Weights,** set of 100 g, lacquered.

17. **Analytical Weights,** set of 1,000 g, platinized.

8. August Sauter, Ebingen (Würtemberg).

Maker of Balances and Weights for Chemists, Pharmacists and Dealers.

Established 1856.—Proprietor since 1874: Louis Armbruster.

Telegraphic and Postal Address: August Sauter, Ebingen, Würtemberg.

Awards: London 1862; Paris 1867; Vienna 1873; Stuttgart 1881, Silver Medal.

1. **Analytical Balance for a charge of 200 g,** Fig. 1, sensitive to 0·1 mg, with short beam of aluminium, beam and stirrup arresters, brush dampers for steadying the pans and rider-slide for weighing 0·1 to 1,000 mg with closed case. The balance is mounted on black plate glass and surrounded by an elegant brass-bound glass case fitted with four aluminium sliding doors. The bearings and knife-edges are made of agate and do not contain any steel or iron.

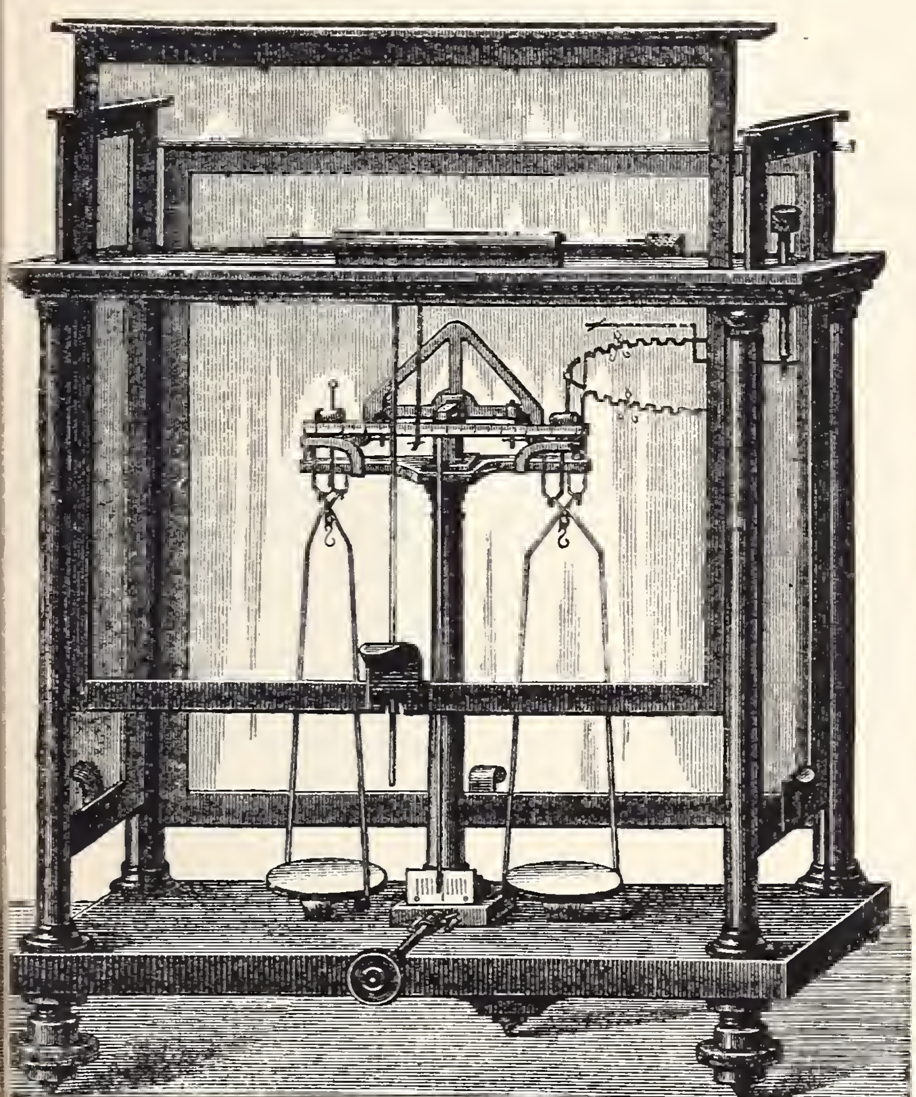


Fig. 1.

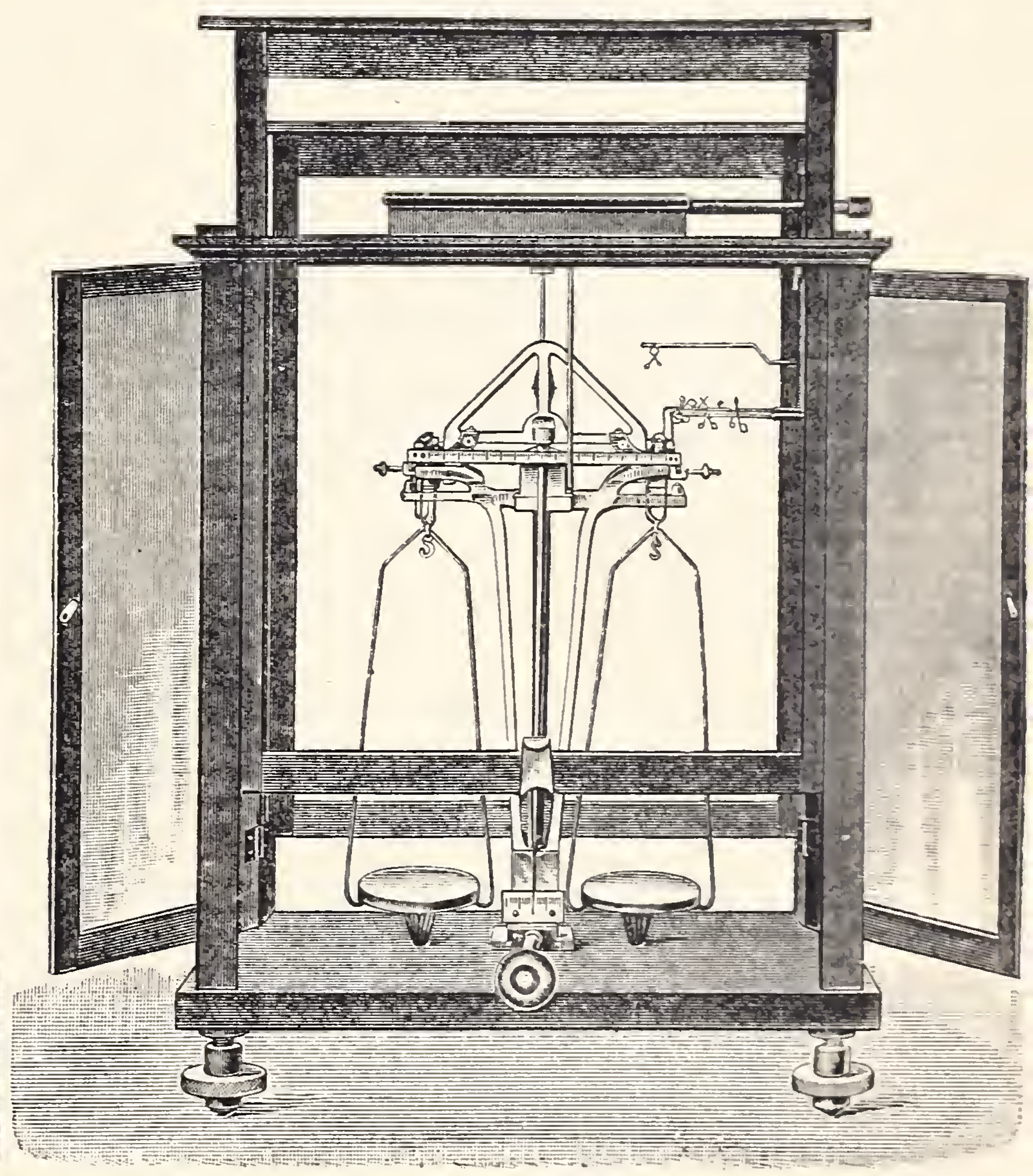


Fig. 2

2. **Analytical Balance for a charge of 200 g,** Fig. 2, sensitive to 0·2 mg, with short beam of aluminium and pans 80 mm in diameter, beam and stirrup arresters, brush dampers for steadying the pans and rider-slide for weighing 0·1 to 1,000 mg with closed case. The balance is mounted on a plate-glass and surrounded by a glass case in mahogany frames fitted with two side doors and balanced front sliding doors. The bearings and knife-edges are of agate, and the use of iron and steel is avoided throughout.

In addition to these analytical balances, the exhibits include a few others adapted for charges of 20, 50 and 100 g respectively, as well as an assay balance.

3. Short Beam Balance for Technical Purposes, with aluminium beam, Fig. 3, sensitive to 2 mg when carrying 200 g, or to 10 mg under a load of 5 kg, with beam stirrup arresters worked by a cam and roller, and brush steadier for the pans.

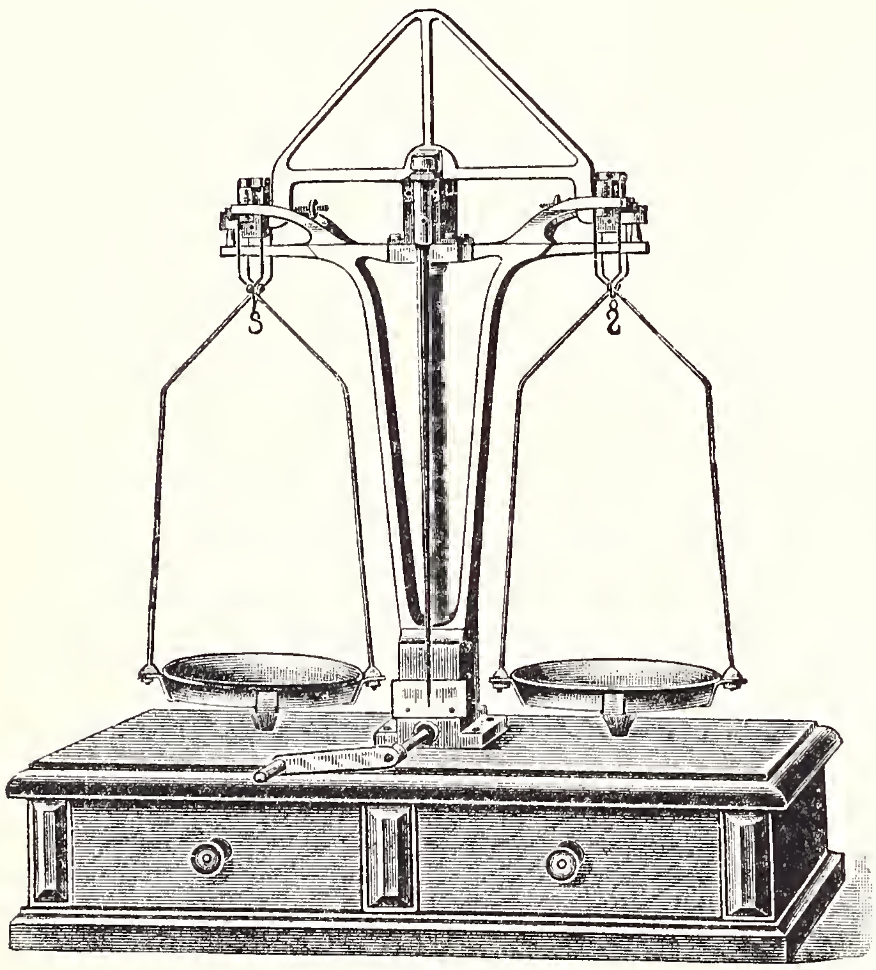


Fig. 3.

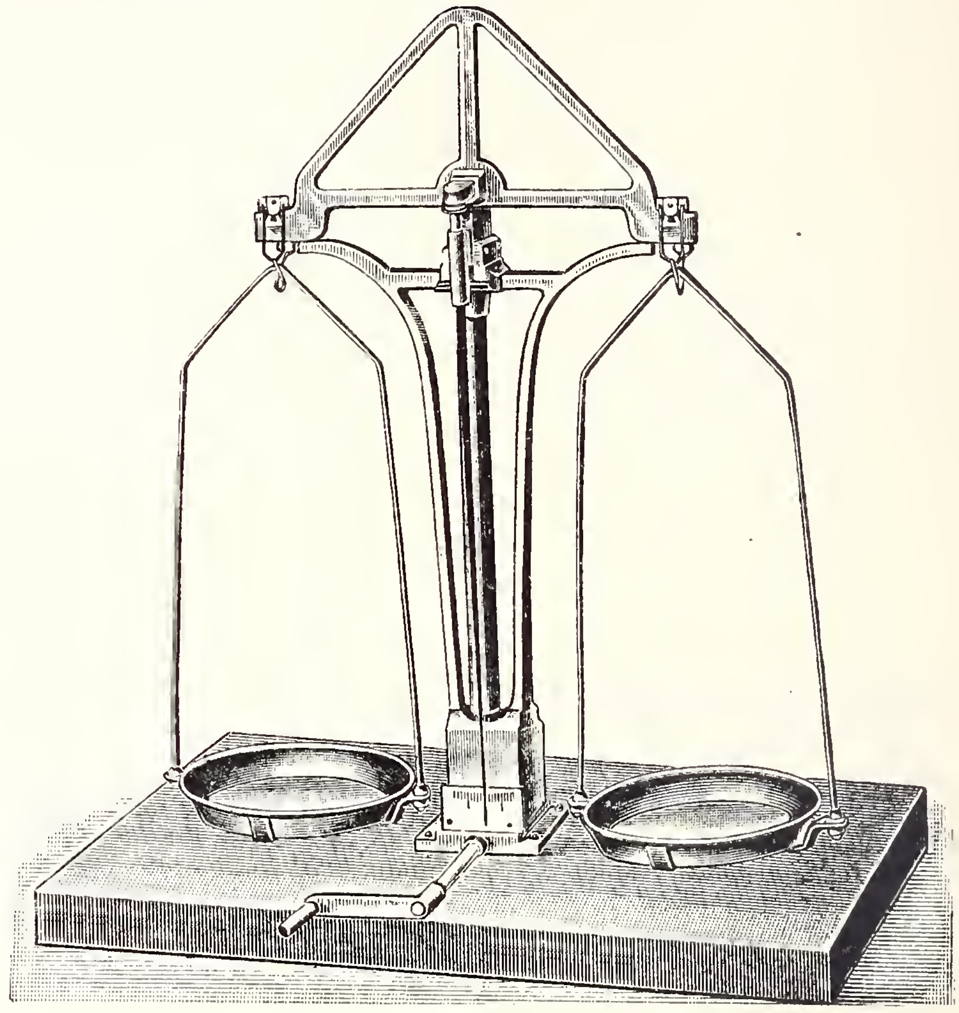


Fig. 4.

4. Short Beam Balance for Technical Purposes, with aluminium beam, Fig. 4, sensitive to 1 mg when carrying 50 g, or to 20 mg under a load of 10 kg, with wheel and cam arrester for the beam.

5. Precision Balance for Technical Purposes for a charge of 50 kg, Fig. 5, sensitive to 50 mg, fitted with pans 40 cm in diameter. The balance has a short beam and is fitted with beam and stirrup arresters for lifting off the central and end knife-edges. The uprights are made of black enamelled iron, the beam, suspenders, pans and chains are of brass. The arresters are worked by a wheel and cam. The degree of sensitiveness can be varied by a sliding weight on the pointer.

A similar balance is made on the same plan for a charge of 100 kg.

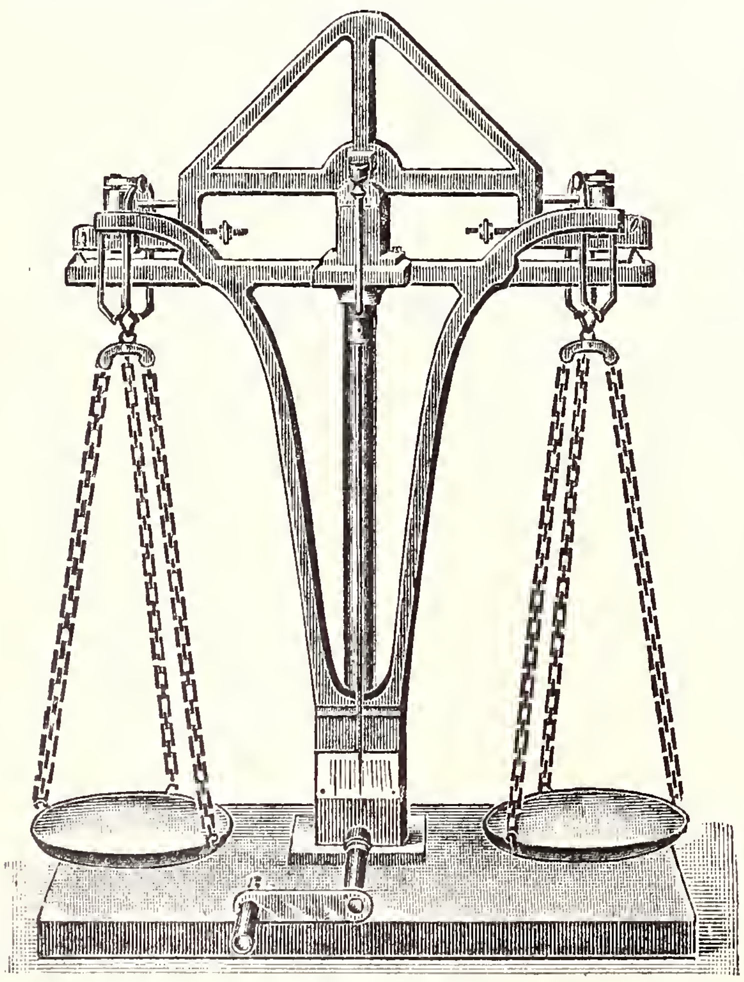


Fig. 5.

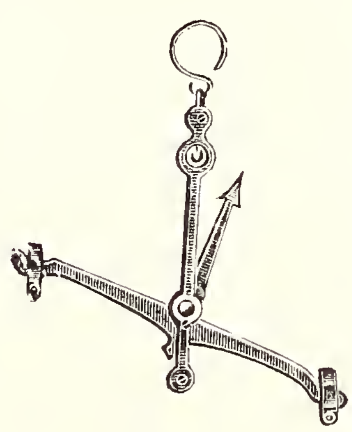


Fig. 6.

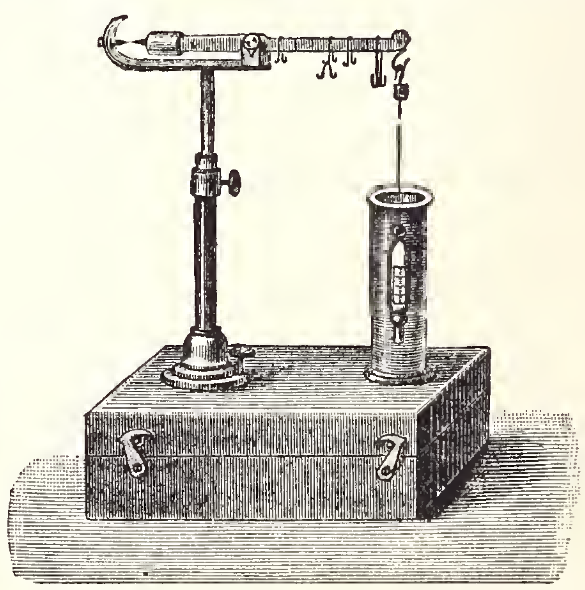


Fig. 7.

6. **Hand Dispensing Scales,** of brass, Fig. 6, of an improved pattern fitted with prismatic knife-edges and suspenders, of various carrying powers.

7. **Westphal's Single Arm Specific Gravity Balance** for fluids. Fig. 7.

8. **Portable Excise Balance** for Weight Inspectors. The beam has on one side two knife-edges situated at distances 1:10 and 1:5 from the central knife-edge. The standard weights of 1, 2 and 2 kg suffice to test weights of 5, 10, 20 and 50 kg. The balance is sensitive within the tenth part of the limit allowed by the German Excise Department.

9. Wilh. Spoerhase, late C. Staudinger & Co.,

Giessen (Hesse).

Physical and Mechanical Works.

(See also Section IIIb.)

This firm was established in 1842 by Carl Staudinger. It was subsequently carried on by Franz Wilh. von Gehren, and since 1888 has been the sole property of Wilh. Spoerhase.

Agencies in Munich, London and Philadelphia. Branches in Munich, 10 Sonnenstr.; London, 81 Page St., Westminster, S.W.

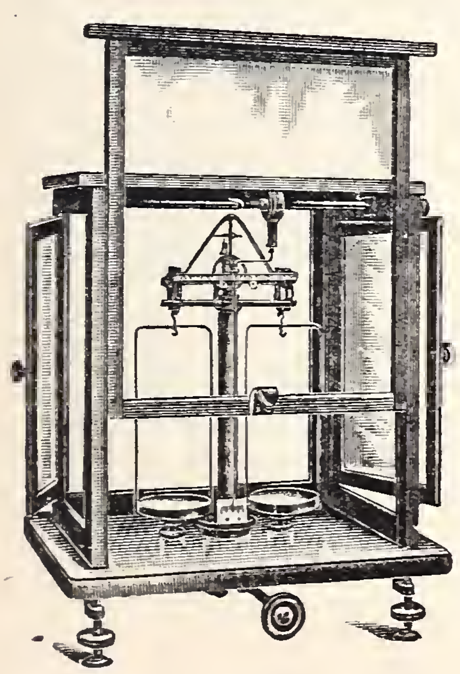


Fig. 1.

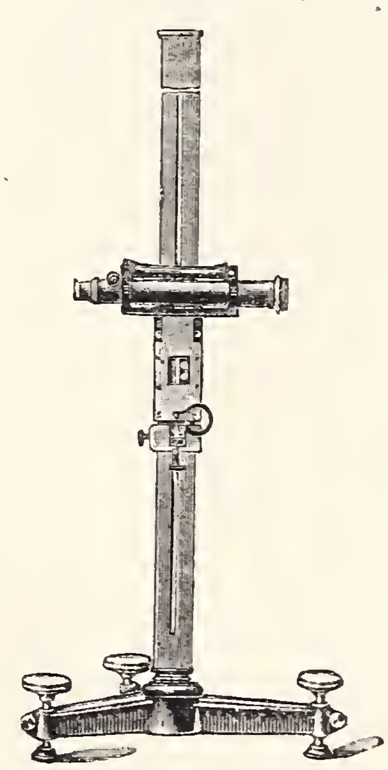


Fig. 3.

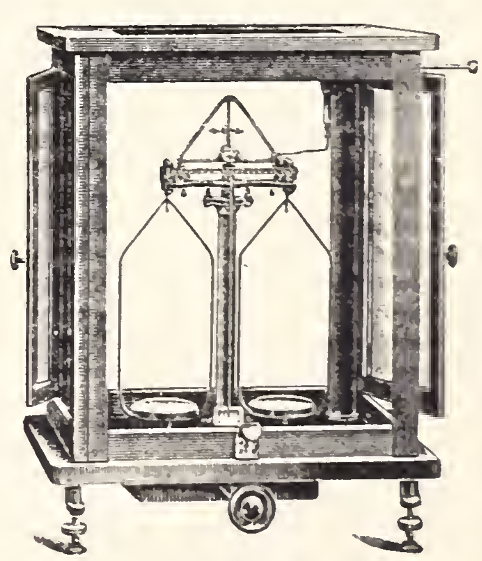


Fig. 2.

1. **Precision Balances and Weights** for Physical, Chemical and Technical purposes. Analytical Balances of the most approved type for use in university and works laboratories. Gold and Silver Assay Balances of finest workmanship, sensitive to 0·01 mg. Specific Gravity Balances. Balances for heavy charges, &c. Fig. 1 and 2.

2. **Cathetometers** of approved original construction: New model with correction of telescope above the zero point of the vernier, so as to directly neutralize prismatic aberrations. Fig. 3.

10. A. Verbeek & Peckholdt, Dresden-Altstadt,

4 Gärtnergasse.

Analytical Balance of constant sensitiveness, with arrangement for arresting the beam, and lifting the central axis from the central planes and the end planes from the end knives. The central knives and the three planes are made of agate. The scale pans are made of sheet nickel and are steadied by means of a brush arrangement. The balance is fitted with sliding rider lifter, having fitted to the rider arm a device preventing the rider from leaping off the hook. The bottom of the case is floored with a black glass plate, its frame being made of mahogany. Both front doors and the removable centre pane are of stout plate glass without wooden frames, and there are two side doors and a sliding window at the back. Each pan takes a charge of 200 g, and an additional charge of 1 mg produces a deflection of 5°.

A distinctive feature of this balance consists in its constant sensibility. The deflection of the pointer, in this case 5° per 1 mg of weight added on one pan, is absolutely independent of the total charge. The deflection is, therefore, directly available for determining the smallest differences of weight without the necessity of accurately balancing the pans. In addition, the balance swings rapidly; the process of weighing is, therefore, considerably shortened by this method.

Price-lists may be had free on application.

II. Astronomical Instruments.

1. Hans Heele, Berlin O. 27, 104 Grüner Weg.

Mechanician and Optician.

(See also Section I, Sub-Exhibition of the Imperial Normal-Aichungs-Kommission, and the Sub-Exhibition of the Imperial Physical and Technical Institute.)

1. Astronomical Objectives for Visual and Photographic Observation.

a. Telescope Objectives, free from secondary spectrum, corrected for rays extending from C to F and made from new, absolutely permanent glasses manufactured by Ed. Mantois, of Paris:

1. 520 mm diameter and 10 m focus
2. 150 - - - 2 - -
3. 120 - - - 1·6 - -

b. Astro-photographic Objective, corrected for the G and Hγ rays. 175 mm diameter and 2 m focus.

c. Apochromatic Objective, satisfying the sine formula and Gauss's postulate, for the requirements of spectrum analysis; 75 mm diameter and 600 mm focus.

d. Telescope Objective made of Jena glass, 175 mm in diameter and 2·9 m focus.

Mr. Friedr. Krüger, the director of the Altenburg Observatory, has published the following criticism respecting the objectives made by the firm:—

"In the meantime I was enabled to exhaustively test the visual objective, and the results proved so unusually satisfactory as to merit general publicity. The objective, computed and polished by Mr. Theodor Heele, has a diameter of 180 mm and a focus of 292·45 cm, the ratio of aperture being accordingly 1:16·2. It consists of glass pairs prepared by Ed. Mantois, of Paris. The material is entirely free from bubbles, perfectly colourless and very transparent.

The tests were carried out in accordance with the directions published by Messrs. T. Cook & Sons (On the adjustment and testing of telescope objectives, Zeitschrift f. Instrumentenk. 1894). The objective satisfied these tests in a manner which stamped it as an achievement of the first order. The observation of bright spots, such as Jupiter, disclosed no traces of colour fringes, also the lunar craters were free from false colouring. I was particularly struck by the well defined colours of fixed stars and the abundance of details discernable on Jupiter and Mars.

The positions of the foci due to rays of different refrangibility were determined after H. C. Vogel's method, by observations on Procyon, Sirius, Castor, Pollux, Capella and Aldebaran. The following were the values obtained by these tests:—

Wave length		Focal differences in millimetres		in $^1/_{100\,000}$ of the focal length	
		Heele	Pauly	Heele	Pauly
C	660	−0·05	−0·08	− 1·7	− 1·8
D	590	−0·09	−0·12	− 3·1	− 2·7
E—b	520	−0·00	−0·00	− 0·0	− 0·0
F	486	0	0	0	0
G	434	+0·36	+2·38	+12·3	+53·3

The data supplied for comparison under the heading of 'Pauly' have been taken from a paper by Prof. M. Wolf, of Heidelberg, entitled: Ueber ein Fernrohrobjektiv mit verbesserter Farbenkorrektion von Dr. Pauly (Zeitschr. f. Instrumentenk. 19. p. 1. 1899). This Objective has a ratio of aperture of 1:21."

2. Refractor of Latest Construction with spherical axes, pierced polar and declination axes and objective having an aperture of 120 mm and a focus of 1·6 m.

3. Knorre-Heele's Universal Micrometer. This instrument comprises 1. a filar micrometer with position circle, 2. a registering micrometer or declinograph, 3. a double image micrometer fitted with double-refracting prism; it has been designed and made from data supplied by Prof. V. Knorre, of the Royal Observatory of Berlin. Fig. 1.

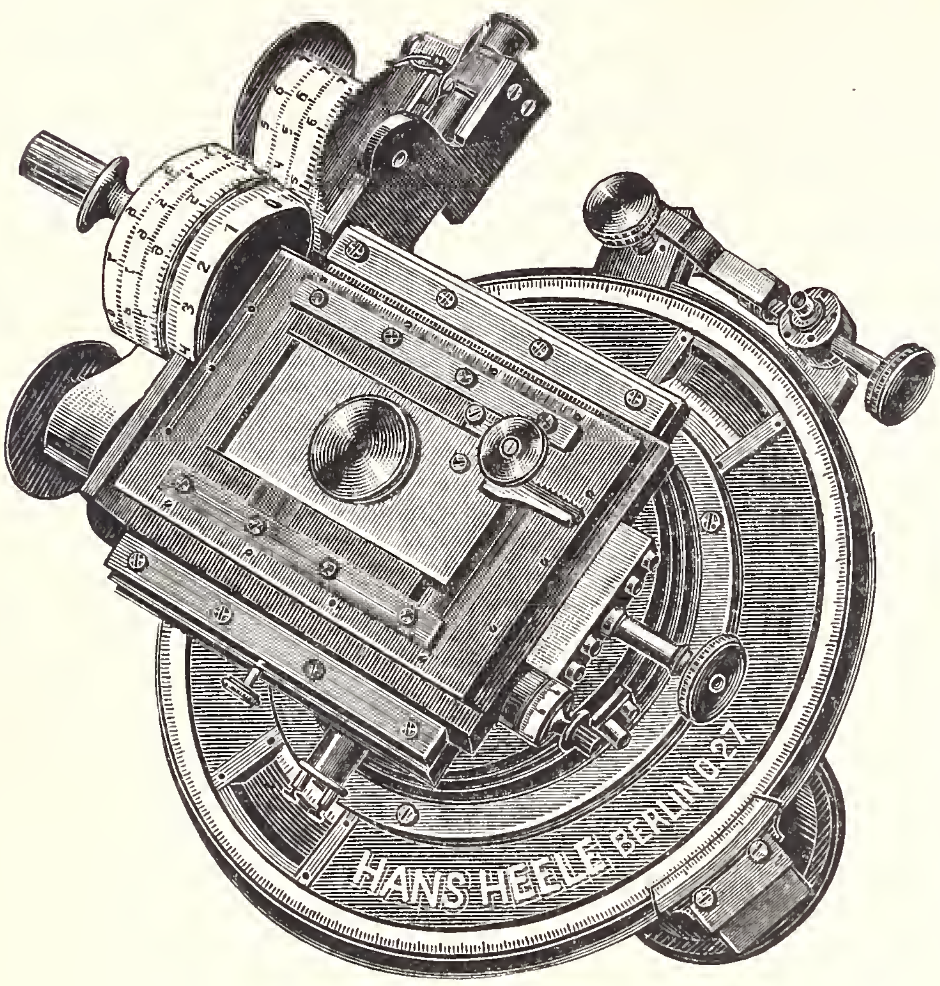


Fig. 1.

This instrument consists of a sleeve fitted with a flange for attachment to the refractor and serving as a carrier for a hollow spindle having two cones and provided at its centre with a graduated circle for the double image micrometer. The lower of these cones is fitted into the sleeve, while the upper cone, that near the eye-piece end, is fitted with a collar carrying the divided circle of the position micrometer, the illuminating appliances for the cross-lines, the micrometer mechanism proper and the recording apparatus.

The micrometer mechanism is fitted with two screws of $1/4$ and 2 mm pitch respectively, one being the measuring screw, the other the declinograph recording screw. The drum of the latter is divided and provided with raised markings in such a manner as to render it available for imprinting the differences of declination in terms of minutes and seconds directly upon an endless paper ribbon, the readings so obtained being correct within extremely small differences, the values of which are ascertainable from a small table.

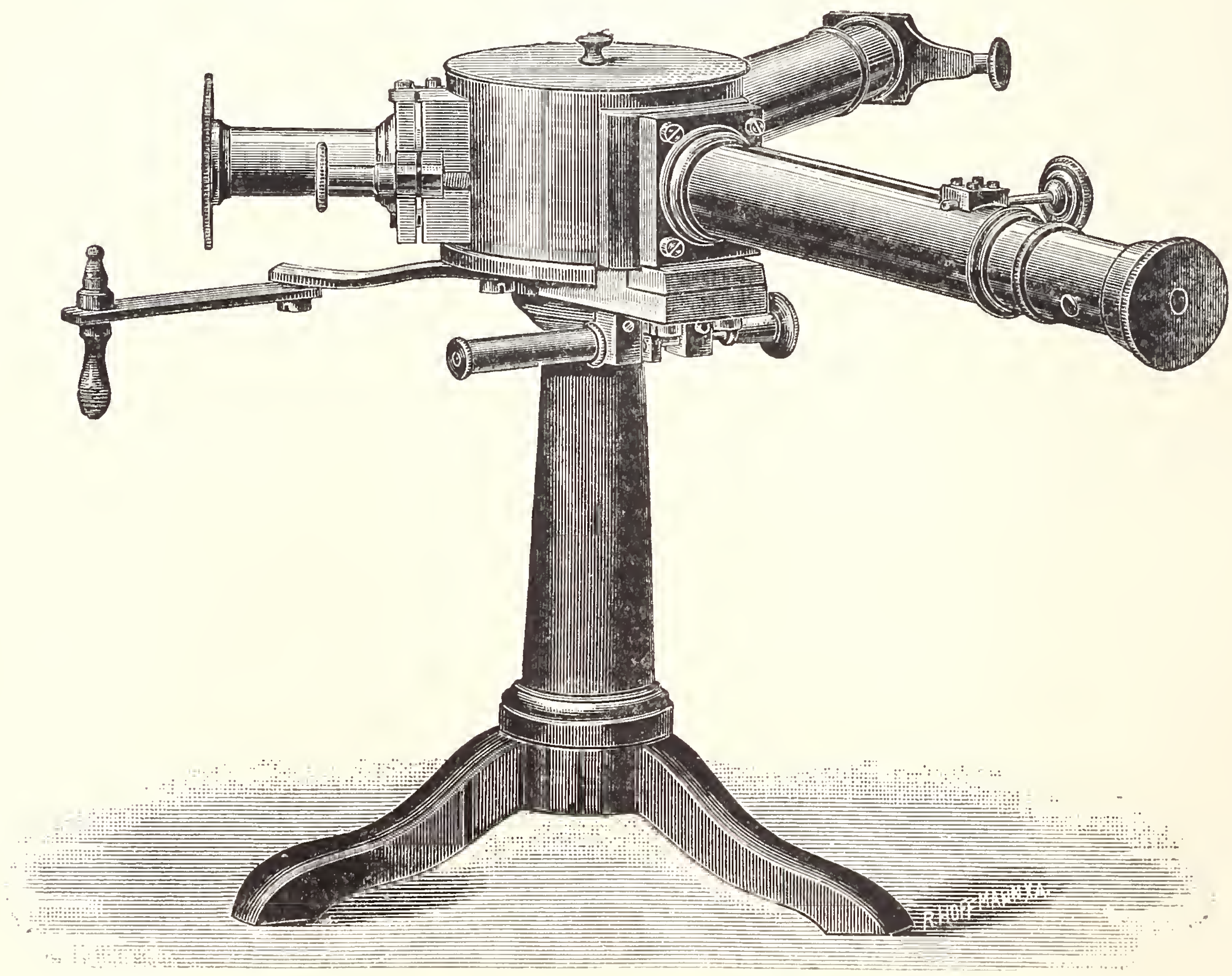


Fig. 2.

The whole of the micrometer mechanism is made of nickel-steel so as to obviate or at least considerably diminish strains arising from changes of temperature.

When using the instrument as a double image micrometer, the tube with its adjustable double refracting prism is slid into the micrometer axis and adjusted by a rack and pinion movement with respect to the cross-lines. The micrometer values are read accurately within 0·1 mm by a scale. The prism, the form and optical properties of which have been computed by Prof. M. Brendel, is not, as in Wellmann's micrometer, situated between the eye and the eye-piece, but between the objective and the plane of the cross-lines and close to the latter. This both improves and simplifies the observation of position angles and distances, since the lines appear single.

The instrument is the property of the Royal Observatory of Berlin.

4. **Spectrum Apparatus** with covered extra-heavy flint glass prism, with telescope of 26 mm aperture and 234 mm focus. Fig. 2.

5. **Various forms of Prisms for Astronomical Purposes.**

Catalogues may be had free on application.—Correspondence in German, French and English.

2. Jakob Merz, Munich, 31 Blumenstr.

Optical Works.

1. **Refractor** of 160 mm aperture, 198 cm focus, equatorially mounted on a cast iron pyramid, polar altitude adjustable from 20 to 60° with clock-work, Foucault's system, filar micrometer with position circle, and field and filar illumination. The divisions on the declination circle can be read from the eye-piece end.

2. **Universal Direct-vision Spectroscope** for stars and solar protuberances.

3. **Helioscope** for solar observations, showing the solar image in neutral tints.

4. **Objective** of 30 cm aperture and 324 cm focus.

5. **Objective** of 26 cm aperture and 319 cm focus.

3. A. Repsold & Söhne, Hamburg, 96 Borgfelder Mittelweg.

(See also Sections I, IIIa and IIIc.)

Transit Instrument and Vertical Circle for fundamental meridian observations. Property of the Royal Observatory of Breslau. Exhibited by the Prussian Ministry of Education.

1. **Transit Instrument:** Objective by Steinheil, of 162 mm aperture and 1·95 m focus, fitted with Repsold's impersonal eye-piece micrometer. Filar and field illumination, also for nadir positions, by a small incandescent lamp near the eye-piece end. The objective and eye-piece heads are interchangeable. The axis can be reversed in its bearings without necessitating the removal of the instrument between the standards.

2. **Vertical Circle for Rotation in Azimuth,** similar to Ertel's vertical circle in Pulkowa. Objective by Steinheil of 162 mm aperture and 1·95 m focus. The cross-lines and field are illuminated by a small incandescent lamp, near the eye-piece end, also in nadir positions. The objective and eye-piece heads are interchangeable. The altitude circle has a diameter of 0·80 m, and reads by four microscopes. The azimuth circle has a diameter of 0·40 m.

4. Clemens Riefler, Nesselwang and Munich (Bavaria).

Mathematical Instrument Works.

(See also Section IX.)

The firm of Clemens Riefler was founded in 1841 and possesses two establishments worked by water power (2 turbines and 3 water-wheels) and giving employment to 100 workmen. The manufacture includes drawing instruments and astronomical clocks, and the annual output amounts to 60,000 drawing compasses and 100,000 other instruments (drawing-pens and small instruments). In addition, the firm has supplied so far 50 astronomical clocks (German patent No. 50,739), 180 mercury compensation pendulums (German patent No. 60,059), and 60 nickel-steel pendulums (German patent No. 100,870). The firm exports to every civilised country and holds 11 international and 12 national prizes.

The present partners in the firm are Dr. Sigmund Riefler and Messrs. Adolf and Theodor Riefler.

Astronomical Clocks and Chronometers of Original Construction.

The degree of precision with which a pendulum clock works depends mainly upon the quality of the escapement and the action of the compensation pendulum. Dr. S. Riefler, engineer in Munich

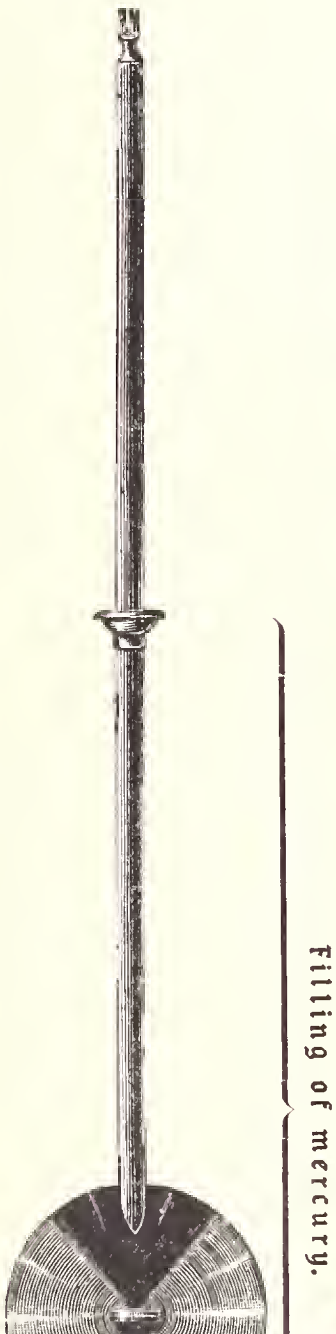


Fig. 1.

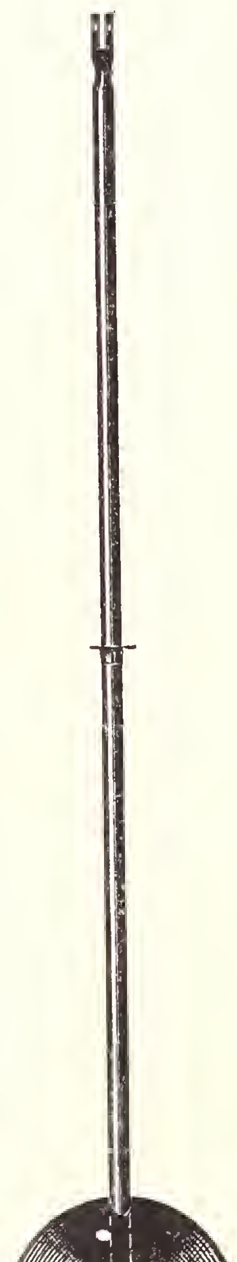


Fig. 2.

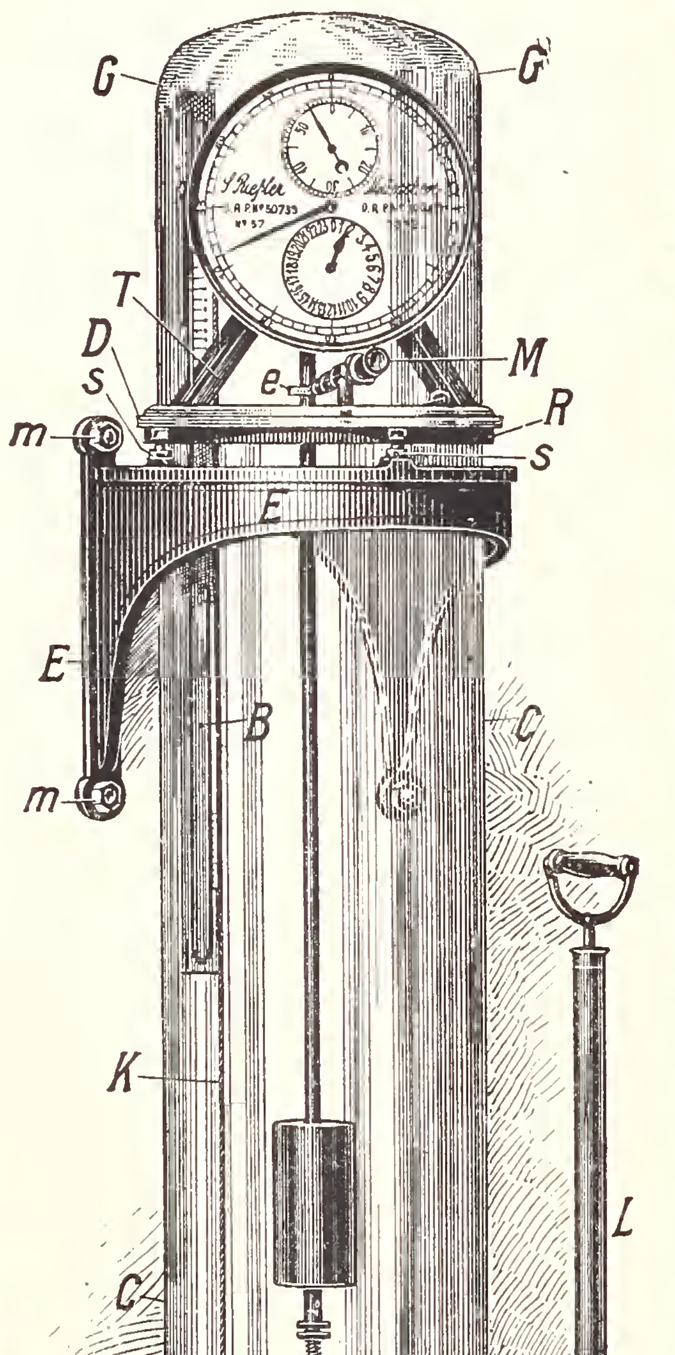


Fig. 3.

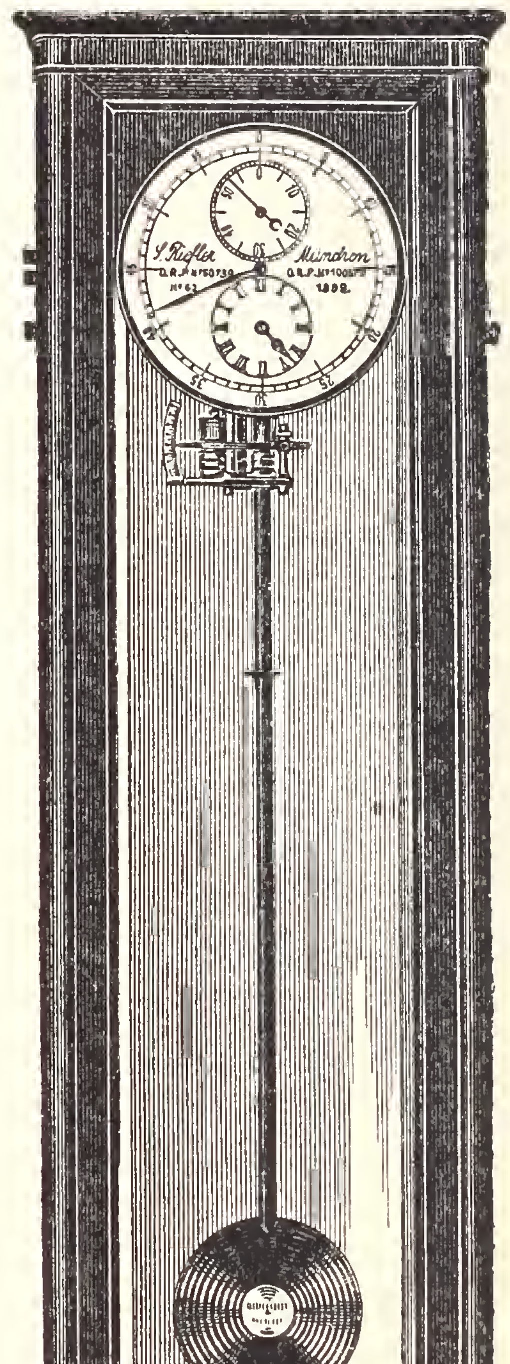


Fig. 4.

and partner in the above firm, after long continued experiments, has succeeded in the construction of an escapement as well as a compensating pendulum which satisfy existing requirements in an unusually high degree. Their construction being now well-known, it will be sufficient to mention that in this form of escapement (German patent No. 50,739) the pendulum oscillates absolutely freely, motion being imparted to it while in the centre of its swing by the pendulum spring itself. The mercury compensation pendulum (German patent No. 60,059, Fig. 1) consists of a thin-walled steel tube, about two thirds of which are filled with mercury.

Dr. Guillaume having, about three years ago, drawn attention to the remarkably low coefficients of expansion possessed by certain nickel-steel alloys, Dr. S. Riefler subjected this material to comprehensive tests. These experiments have shown it to be, under certain conditions, eminently suitable for the construction of compensation pendulums and have resulted in the construction of a nickel-steel compensation pendulum (German patent No. 100,870, Fig. 2), which consists of a rod of nickel-steel and compensating tube and the lenticular body having its axis of gravity resting upon the compensating tube. The coefficient of expansion of the compensating tube bears a definite relation to that of the nickel-steel rod. For this end the compensating rod is not made of a single tube but consists of two tube pieces of different metals, whose coefficients of expansion differ widely. The lengths of the two tubes are such as to jointly produce in every case the desired compensation, both rods together having in all pendulums the same length at the assumed normal temperature.

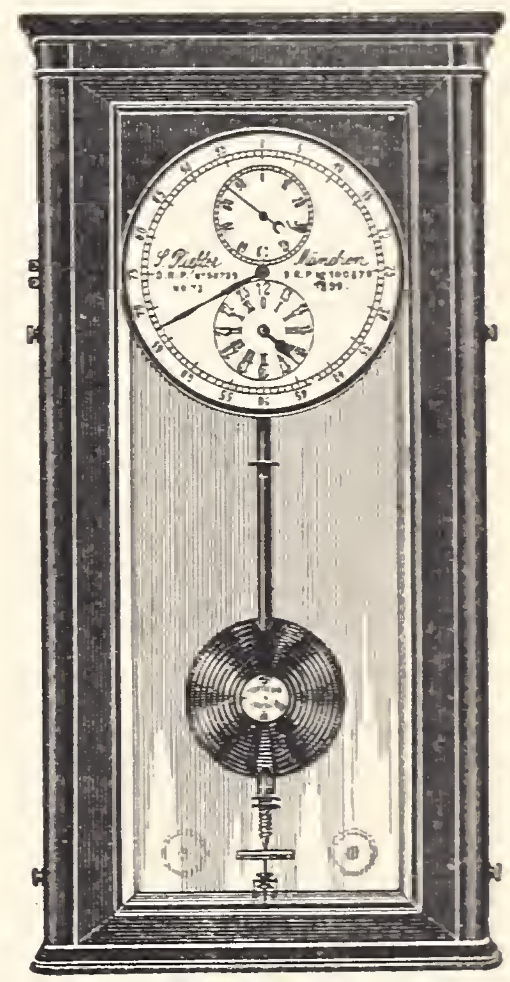


Fig. 5.

In order to eliminate the influence of changes in the barometric pressure upon the movement of clocks, the latter are constructed in the form of 1. Clocks with air-tight covers, and 2. Clocks with barometric compensation.

1. The Clocks fitted with air-tight covers (Fig. 3) are mounted in a glass cylinder and hermetically closed by a ground-on bell glass. This manner of mounting possesses the additional advantage of rendering the mechanism of the clock easily accessible, as it is only necessary to lift off the bell glass.

The clock is driven either by an ordinary set of weights, the cord of which passes through a stuffing box, or it is driven electrically. In the latter case, a weighted driving lever attached to the minute spindle of the movement is allowed to gradually sink to a certain depth and then raised electrically at intervals of 5 to 8 minutes, the current being supplied by two dry cells.

The amplitude of the oscillations can be read accurately within $^1/_{10}$ minute of arc by a microscope and glass scale mounted within the bell glass.

An electric contact marking seconds transmits the oscillations of the pendulum to the chronograph. It is actuated by a wheel movement and does not interfere with the accuracy of the clock, as shown by practical and independent observation.

2. The barometric compensation of the pendulum consists of a circular aneroid attached to the pendulum rod. The upper box of the aneroid is loaded by a weight which, following the fluctuations of the atmospheric pressure, alternately rises and falls. When the air pressure increases, the aneroid chambers are compressed, the said weight rises a little and thereby imparts to the pendulum a certain acceleration which is equivalent to the retardation which, in the absence of this device, the pendulum would suffer in consequence of the increased density of the air.

The weight referred to consists of metal disks, the number of which may be increased or diminished as may be required to obtain perfect compensation. The indications of the aneroid can at any time be compared with those of a mercurial barometer by means of a dial and pointer attached to the instrument.

The following clocks are exhibited:

1. **An astronomical Clock** (Fig. 3) in an air-tight glass case, fitted with a free escapement (German patent No. 50,739), nickel-steel pendulum (German patent No. 100,470) and electrical contact marking seconds.

2. **An astronomical Clock** (Fig. 4) in mahogany case with free escapement (German patent No. 50,739), nickel-steel pendulum (German patent No. 100,870), barometric compensation and electrical contact marking seconds.

3. **A Chronometer** (Fig. 5) with decimal hour dial (120,000 pendulum beats per day), in mahogany case, with free escapement (German patent No. 50,739), nickel-steel pendulum (German patent No. 100,870) and electrical contact marking seconds.

With reference to this clock it may be interesting to note that, although there is no immediate necessity for relinquishing the customary division of time in favour of decimal time, yet it seems that the question of the decimal division of time is still engaging considerable attention, so much so that it appeared desirable to take due cognizance of one or the other of the propositions advanced to this end; and of these propositions the only one likely to be practically realizable appears to be the division of the day into 24 hours, as heretofore, the hour into 100 minutes and each minute into 100 seconds. Each day would accordingly embrace $24 \times 100 \times 100 = 240{,}000$ seconds. A pendulum beating these decimal seconds would, however, be inconveniently short, and hence it has been found desirable to cause the pendulum to beat double seconds, so as to make 120,000 oscillations per day, its length being 515·2 mm. The terms minute and seconds are in that case appropriately disused, so as to obviate misconceptions, a better plan being to write the submultiples of the hour in the form of decimal fractions.

5. C. A. Steinheil Söhne, Munich, 7 Theresienhöhe.

Optical and Astronomical Works. Established 1855.

Proprietor: Dr. Rudolf Steinheil.

(See also Sections Vb, Ve and Vf.)

I. Optical Parts of Astronomical Instruments.

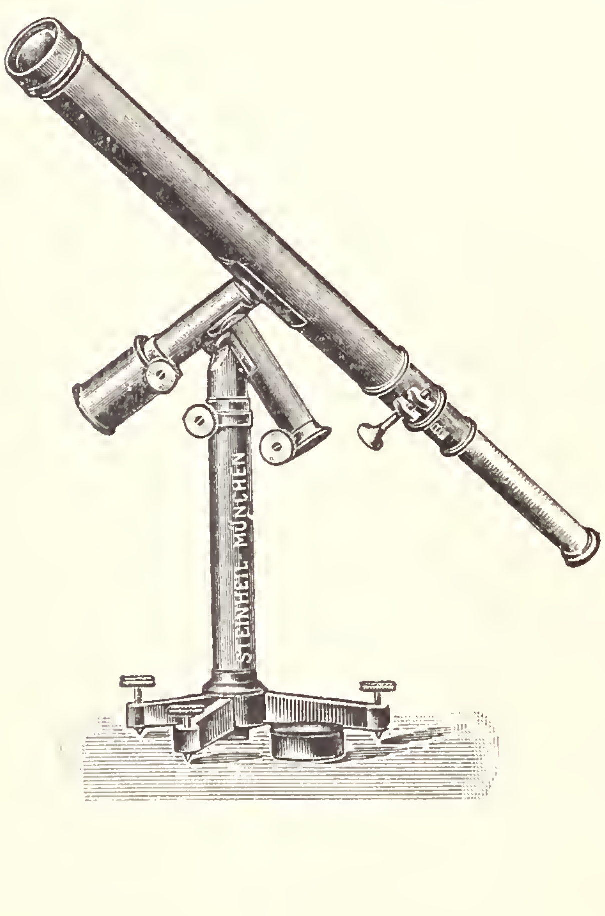
A. Telescope Objectives.

1. **Binary Objectives:** a. of ordinary flint and crown glasses, ratio of aperture 1:8 to 1:30; b. of new Jena glasses without secondary spectrum, ratio of aperture 1:18 to 1:30.

2. **Triple Objectives** (of great light-gathering power): a. of ordinary flint and crown glasses, ratio of aperture 1:4 to 1:8; b. of new Jena glasses without secondary spectrum, ratio of aperture 1:10 to 1:18.

Any of these objectives can, if desired, be achromatized for the chemical part of the spectrum for photographic purposes.

The mounts are of brass in the case of the smaller objectives not exceeding 5 inches, but steel is employed for the mounts of the larger objectives. Nickel-steel, costing about 10 per cent in excess, may be substituted for steel so as to obtain greater uniformity in the expansion of the mount and glass at different temperatures.



B. Eye-pieces.

1. **Astronomical Eye-pieces:** a. Mittenzwey's AD eye-pieces, being improved Huyghenian eye-pieces, forming the image between the lenses and having an apparent field of about 50°. b. Achromatic AF micrometer eye-pieces, forming the image in front of the lenses and embracing an apparent angle of about 40° C. c. Monocentric or AG micrometer eye-piece, free from reflection, forming the image in front of the lenses and having an apparent field of about 36°. d. Aplanatic or AH micrometer eye-piece; free from reflection, forming the image in front of the lenses and subtending an apparent angle of about 20°.

2. **Terrestrial Eye-pieces:** a. Ordinary or BD terrestrial eye-pieces consisting of four plano-convex lenses embracing an apparent angle of about 44°, adapted for binary telescope objectives. b. Achromatic or BF terrestrial eye-pieces consisting of four achromatic objectives and embracing an apparent angle of about 40°; adapted for triple objectives.

II. Complete Instruments.

1. **Small Telescope** with table stand for astronomical and terrestrial observations, as shown in the illustration, with portable polished box.

The telescope is of brass and is fitted with rack and pinion movement, a terrestrial and three astronomical eye-pieces and a dark-glass.

The telescope is equatorially mounted and moves by hand; the stand is fitted with clamping screws, elongation-tube and tripod with elevating screws.

2. **Photographic Telescope** with negative magnifying lens.

The tube is of brass and fitted with an objective of 68 mm ($2^3/_4$") aperture and a negative (Barlow) lens, the resultant equivalent focus being about 750 cm. The extreme length of the instrument is 120 cm.

The outfit includes an instantaneous shutter with pneumatic and hand release, a finder and focussing screen for solar images, rack and pinion for accurate focussing, camera with focussing screen and two dark-slides for 9×12 cm plates.

The camera can be rotated round the telescope axis and is fitted with a flange graduated into whole degrees.

This telescope is primarily designed for solar and lunar photography, the diameter of the image being about 7·5 cm. There is no stand, the instrument being best mounted upon the tube of a large clock-driven refractor.

3. **Comet-Finders.** Small low power telescopes of considerable light-gathering power and embracing a correspondingly large field. Adapted for the detection by hand of comets and faint objects.

6. O. Töpfer, Potsdam.

Maker of Astronomical Instruments.—Established in 1873.

(See also Section IV.)

1. **Protuberance Spectroscope,** as suggested by H. C. Vogel. This spectroscope satisfies two essential requirements: it possesses a high dispersion and great stability. It is fitted with two quintuple prisms of the direct vision form, one of which can be readily withdrawn. A large surface is exposed for attachment to the telescope. The anterior part of the spectroscope is mounted on a rigid tube which is freely perforated so as to prevent the accumulation of heat within the tube. The slit is adjusted by a key projecting outside the tube. The telescope is fitted with coarse and fine adjustments for observing certain regions of the spectrum, a graduated arc serving to predetermine the desired position. The spectra or protuberances are measured by a differential eyepiece-micrometer. The entire spectroscope can be made to rotate in its shell for tangentially or radially adjusting the slit with respect to the solar edge. This rotation being likewise controlled by a divided circle, the angular position of a protuberance at the sun's edge can be read off with ease.

2. **Prof. Müller's Wedge Photometer** for celestial photometry, available for stars up to the eighth magnitude. The mount is of the elbow type and is adjustable for any polar altitude. The objective (aperture 55 mm, focus 60 cm) is situated at the end of a lateral rotating arm. In front of the objective is mounted, in a revolving casing, a totally reflecting prism, to which is attached a graduated arc showing star declinations. The hour circle is divided into intervals of 4 minutes of time and the hour angles are adjusted by a plain pointer. Within the large cube there is a second totally reflecting prism. The eyepiece sleeve is directed towards the poles, the observer need therefore never change his position. The eyepiece is replaced by the wedge-photometer proper, which is provided with means for registration. The wedge is made of neutral glass and is 65 mm long. A displacement of 1 mm corresponds to a magnitude interval of 0·2. Two closely apposed steel laminae are fitted at right angles to the movement of the wedge in the common focus of the objective and photometric eyepiece. The eyepiece sleeve is fitted with a small position circle, by means of which the photometer can be adjusted in such a manner as to place the laminae in the direction of the diurnal movement whilst the stars pass through the field within the interval between the laminae, thus traversing the wedge at right angles to the direction of the movement.

Two instruments of this kind were used by Müller and Kempf on an expedition to the summit of the Etna, which was undertaken with the object of studying the absorption of stellar light by the atmosphere of the Earth. (See Publications of the Astro-physical Observatory of Potsdam, XI, p. 227.)

Both instruments are the property of the Royal Astro-physical Observatory of Potsdam.

7. Carl Zeiss, Optical Works, Jena.

(See also Sections Vb, Vc, Vd, Ve and Vf.)

Astronomical Objectives for Observation and Photography.

Ever since the beginning of this century many futile attempts have been made to remove or at any rate diminish the secondary spectrum in astronomical objectives. This failure was mainly due to want of suitable glasses, having—at least as far as the visual part of the spectrum is concerned—their partial dispersions very uniformly proportional.

The efforts of Dr. Schott, of Jena, resulted for the first time in 1886 in the production of glasses satisfying these special requirements. Unfortunately, these glasses were not only extremely difficult to produce, but they lacked permanency, owing to the substitution of phosphoric and boric acid for silicic acid.

During the last few years Dr. Schott has successfully resumed the experimental production of suitable durable glasses. The principal constituent of these new glasses is silicic acid, the glasses are permanent, and yield within the spectral region of C to F an almost completely proportional gradation in the partial dispersions.

The binary astronomical objectives made from these new Jena's glasses disclose at most a slight tertiary residual spectrum. Owing to the completeness with which the luminous rays are brought to a focus these objectives yield a considerably improved brightness and defining power and admit of the use of high-power eyepieces.

The trinal objectives consist of three different kinds of glasses, their ratio of aperture is 1:12 and they are completely corrected spherically and chromatically within the spectral region extending from C to G', which renders them equally well adapted for observation and photography.

Astro-photographs of extensive stellar areas can also be taken by means of photographic lenses made from the new glasses as the images formed by these objectives are extremely small and sharp, and also because the latter possess in proportion to their apertures a considerably increased chemical efficiency.

1. **Apochromatic Binary Telescope Objective** without secondary spectrum of 550 mm aperture and 10 m focus. Relative aperture 1:18. From Jena telescope-crown and telescope-flint.

2. **The same Objective** of 325 mm aperture and 5·8 m focus. Relative aperture 1:18.
These objectives are completely corrected chromatically within an intermediate zone with respect to the spectral region extending from C to F, the whole of the rays are therefore very nearly brought to an accurate focus. The secondary spectrum is, by this means, reduced to about $^1/_{10}$ of that existing in ordinary telescope objectives, as far as visual observations are concerned.

3. **Apochromatic Trinal Objective** of 180 mm aperture and 2·80 m focus. Ratio of aperture 1:15·5. The secondary spectrum as well as the chromatic difference of spherical aberration (Gauss's postulate) are, within the spectral region from C to G', reduced to an imperceptible residue. This objective is therefore available, without the addition of a compensating lens, for the photography of the heavens as well as ocular observation.

4. **A similar Objective** of 128 mm aperture and 1·53 m focus. Ratio of aperture 1:12.

5. **Apochromatic Aplanat** for astro-photographic purposes. Diameter of objective 120 mm, focus 1·00 m. Ratio of aperture 1:10. The secondary spectrum is corrected within the spectral region from F to h. In spite of the moderate aperture the objective yields great chemical intensity owing to the complete concentration of the chemical rays.
This objective is adapted for the photography of star-clusters and for cartographic photography.

6. **Objective-prism of flint-glass** having a refractive index of 1·57 and a refracting angle of 45°, for the photography of stellar spectra with the aid of short focus objectives of wide aperture.

7. **Equatorially mounted Travelling Telescope**, suggested by L. Mach. Effective aperture 12 cm.

8. **Large and small Mirrors** made of L. Mach's speculum metal (magnesium-aluminium alloy).

Price-lists of astronomical objectives and instruments, published in German, French and English, may be had free on application.

III. Surveying and Nautical Instruments.

a. Geodetic Instruments.

1. Carl Bamberg, Friedenau near Berlin, 39/41 Kaiserallee.

Scientific Instrument Maker and Optician.

Established 1871.

Telegraphic address: Bamberg-Friedenau.—Telephone: Friedenau No. 14.

(See also Sections IIIc and IV.)

1. **Revolving Transit Instrument** with elbow telescope of 40 mm aperture, for astronomical and surveying purposes. The azimuthal circle is fully divided and covered, its diameter being 210 mm. Both circles read by microscopes. The instrument is fitted with vertical hanging bubbles and the transit axis is counterpoised on the balance beam principle. The latter is fitted with mechanism for lifting it out of its bearings. The movement of the vertical spindle is adjustable. The specification includes a finder, field-illumination and moderating glasses, bubble alhidada with clamping micrometer rotating through 90°.

2. **Precision Heliotrope.** This instrument differs from the simple Bertram heliotrope in the following respects:—The signalling tube is mounted upon the signalling axis, which can be rendered vertical by means of a spirit-level. For this purpose a heavy iron screw or bolt fitted with a movable head and capable of horizontal adjustment is made to hold the screw of the signalling axis, which also fixes the point whence the signals proceed.

3. **Plumbing staff,** for showing the position of points along a vertical line. A decimetrical disk is employed to determine linear differences in the projection of points situated at different elevations, which cannot be measured by direct means.

4. **Bolts** for sharply marking the terminal and intermediate points of base-lines.

The objects 2, 3 and 4 are the property of the Royal Survey Office of Berlin.

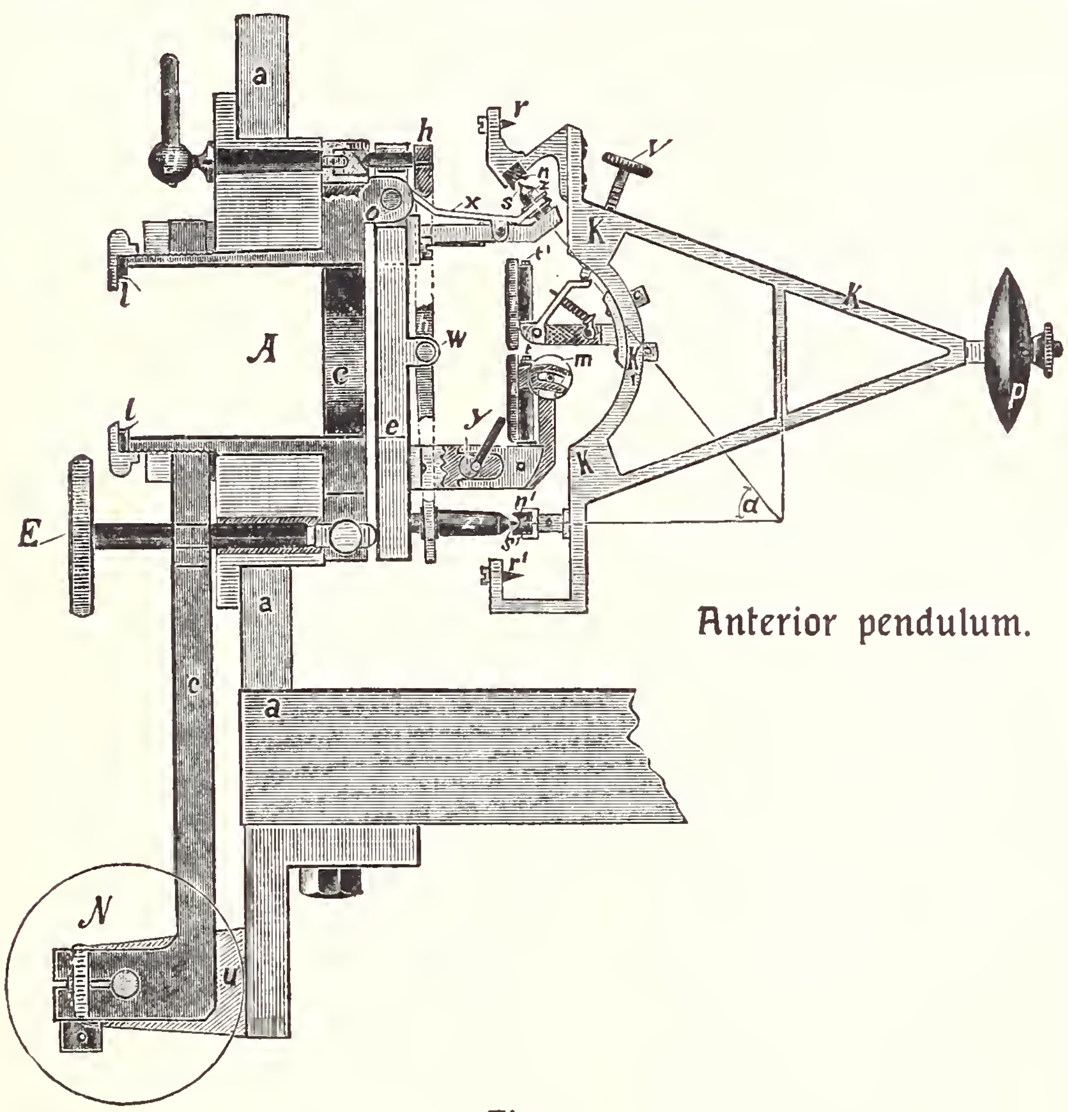
2. J. & A. Bosch, Strassburg, Alsace.

Philosophical Instrument Makers.

(See also Section I.)

Triple Horizontal Pendulum constructed on Rebeur-Ehlert's principle, Figs. 1 and 2, consisting of a horse-shoe cast iron casing within which are pivoted three equidistant pendulums of the form of isosceles triangles, suitably balanced, weighing 110 g each. Each end of the base is fitted with agate bearings nn', the upper of which is part of a sphere with a paraboloid depression, whereas the lower has a v-groove. The pendulum is fitted with two firmly supported steel pivots ss', which rest upon the agate bearings. The lower pivot is horizontal, the upper points towards the intersection of the line through the centre of gravity and the horizontal pivot produced. The line joining the

centres of the bearings, i. e., the axis of rotation, is 80 mm long, and the distance of the centre of gravity from this axis is approximately 62 mm. The total weight of the anterior pendulum is 185 g, that of each of the two posterior pendulums 211 g. The axis of rotation can be inclined more or less with respect to the vertical line so as to establish any desired degree of sensitiveness. The pendulum can, accordingly, be made to move perceptibly in response to changes of inclination within the thousandth part of a second of arc. This horizontal pendulum is, therefore, by far the most sensitive apparatus for observing oscillations of the vertical line under the influence of solar heat and lunar attraction. Its sensitive response to the slightest changes in the inclination of the vertical line renders the pendulum adapted for seismographic observations, both in near and distant earthquakes. The combination of three pendulums serves to determine the time and direction, amplitude and periodicity of the observed seismic disturbances. The movements of the pendulums are registered optically. For this purpose each pendulum is fitted with a concave mirror and the casing has affixed to it a stationary mirror, all having definite radii of curvature. A lamp and registering apparatus is placed in the centre of curvature of these mirrors. The rays reflected by the mirrors pass through a horizontal cylindrical lens, mounted in front of a drum covered with sensitized paper upon which the concentrated rays trace sharply defined points, those due to the fixed mirror serving as a time marker.



Anterior pendulum.

Fig. 1.

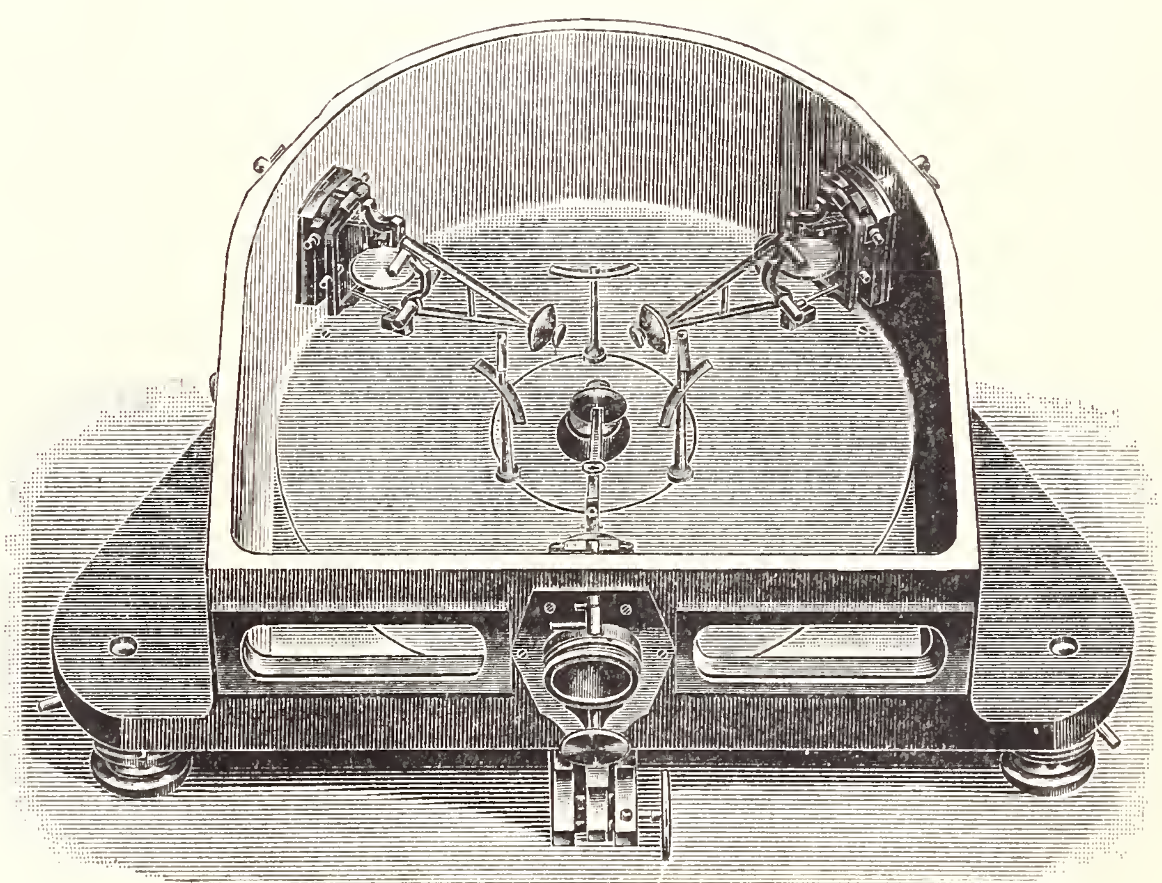


Fig. 2.

3. R. Fuess, late J. G. Greiner jr. & Geissler,

Steglitz near Berlin, 7/8 Düntherstr.

Mechanical and Optical Works.

(See also Sections IV, Vb, Vd and Vg.)

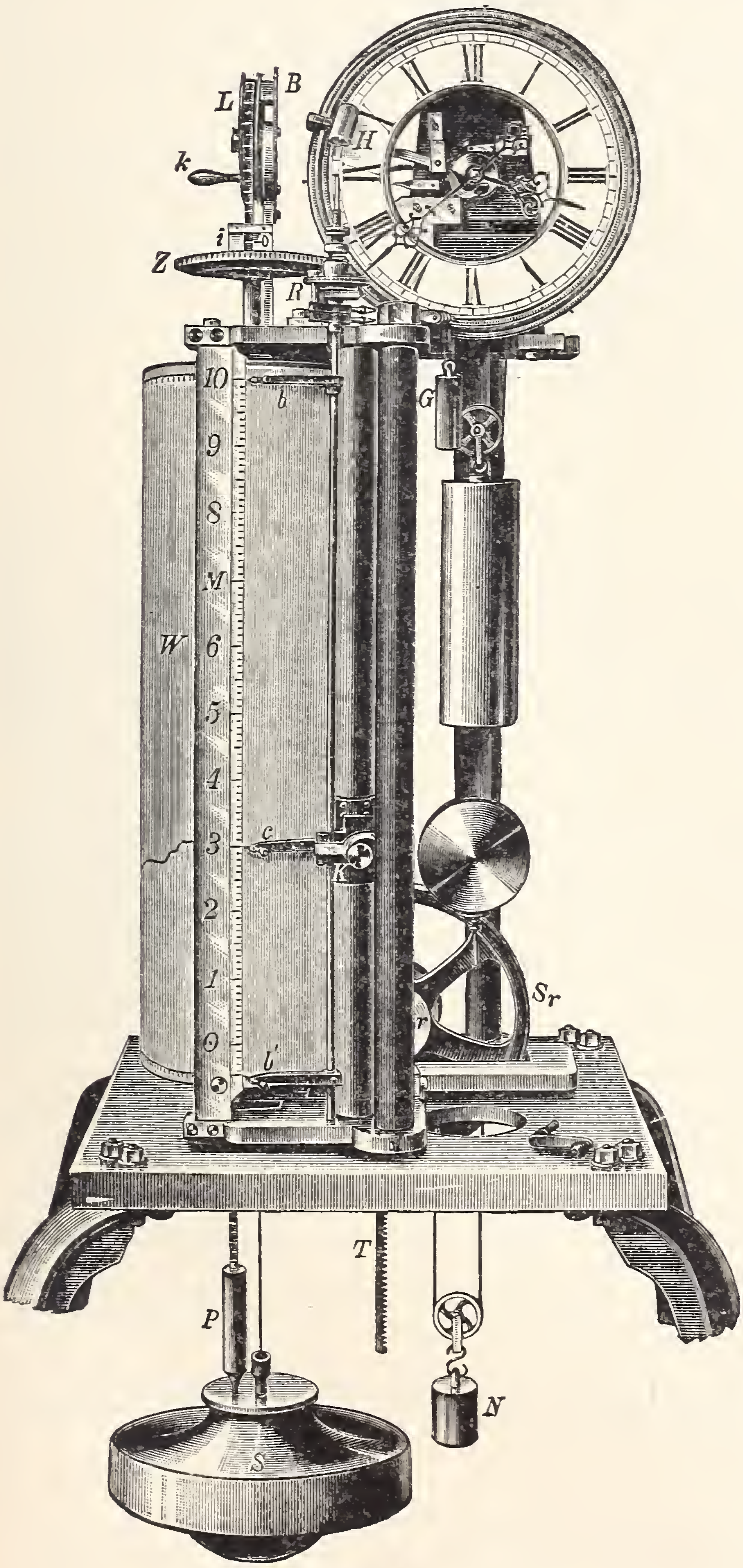


Fig. 1.

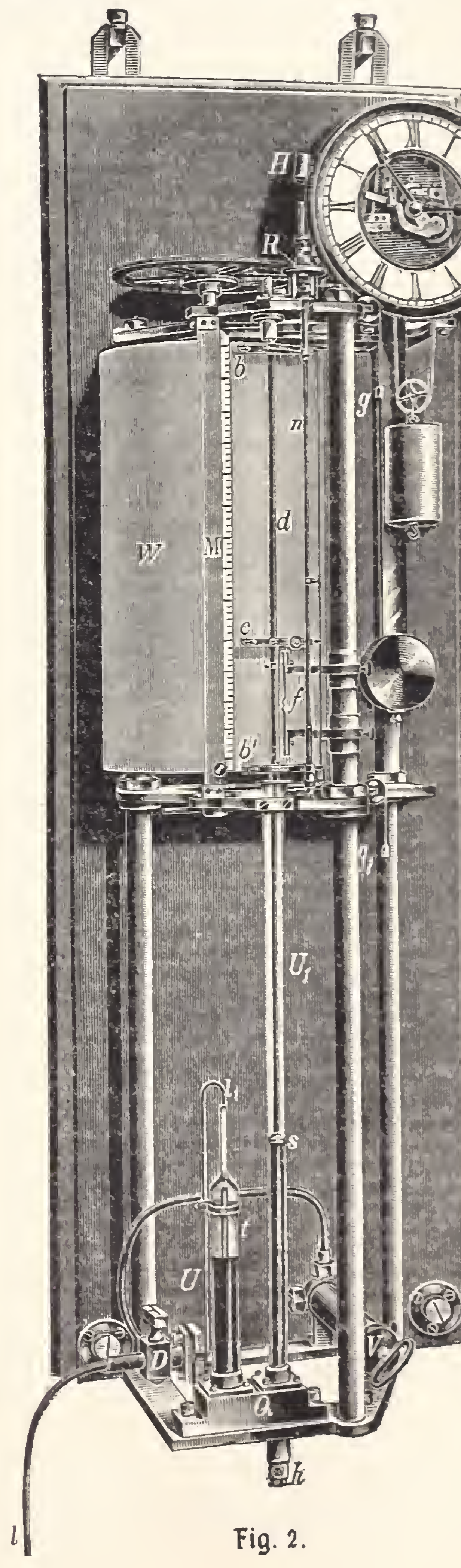


Fig. 2.

Seibt-Fuess's Automatic Water-mark Registering Float, as described in the Centralblatt der Bauverwaltung 1893, p. 542; 1897, p. 563. Fig. 1.

Seibt-Fuess's Automatic Water-mark, as described in the Centralblatt der Bauverwaltung 1897, p. 563.

Seibt-Fuess's Automatic Pneumatic Water-mark, as shown in the illustration and as described in the Centralblatt der Bauverwaltung 1896, p. 202. Fig. 2.

Ordinate and Abscissa Reducer, as described in the Centralblatt der Bauverwaltung 1896, p. 572.

These instruments are the property of the Prussian Government Board of Public Works.

4. Max Hildebrand, late August Lingke & Co.,

Freiberg, Saxony.

Maker of Astronomical, Surveying, Mining and other Instruments.

Established 1791.

(See also Section III b.)

1. **Universal Instrument** with circles of 21 cm diameter, each division of the microscope drum reading to 1". The telescope is coudé and has a focus of 43 cm and an aperture of 41 mm. It is fitted with an eyepiece micrometer, and the telescope spindle is pierced for field-illumination. The spirit-level is of the Horrebow type. The revolving horizontal circle is centrally clamped against the tripod and firmly connected with it by tightening a thumb-screw projecting from the tripod ring. The controlling telescope can likewise be firmly clamped to the tripod so as to disclose with absolute certainty any changes in the position of the tripod as well as the horizontal circle while making measurements. The manner in which the horizontal circle is fixed and the method of mounting the controlling telescope are new.

2. **Large Level Tester,** adapted for the reception of complete instruments so as to test their spirit-levels without the necessity of dismounting them, to illustrate which the universal instrument is exhibited standing on the level tester. The various instruments placed upon the tester are balanced by a set of levers encased in the base of the apparatus. One end of these levers acts upon the movable arm of the tester, whereas the other end supports a scale-pan (absent in the exhibit), upon which are placed weights corresponding to the weight of the instrument resting on the tester. The movable arm of the tester is balanced by a sliding weight, until perfect equilibrium is established, and, that the measuring screw may work under uniform pressure whatever may be the weight of the instrument placed upon the platform of the tester, a small additional weight is provided.
The instrument is also adapted for testing any single spirit-level with or without its mount. For the examination of striding-levels the tester is fitted with elevated arms, and a separate stage is provided for simultaneously examining two levels (e. g. Horrebow levels).

This instrument is the property of the Royal Geodetic Institute and Central Office of the International Geodetic Association at Potsdam.

5. A. Repsold & Söhne, Hamburg, 96 Borgfelder Mittelweg.

(See also Sections I, II and III c.)

Universal Transit Instrument, available both as a transit instrument in all azimuths and as a theodolite. The objective has a diameter of 68 mm and a focus of 86 cm. The three eye-pieces supplied with the instrument yield magnifying powers of 120, 84 and 56. The telescope is fitted with a

Repsold registering micrometer, capable of rotation through 90°. For Horrebow observations the eyepiece end is fitted with two juxtaposed bubbles which can be finely adjusted by a screw working below their bearings. The circle is fitted with an alhidada bubble, and the zenith-screw works excentrically.

The carriers of the lateral friction rollers are mounted upon a balance beam supported below the middle friction roller so as to obviate unequal pressure on the lateral rollers. The horizontal axis can be reversed by means of a horizontal lever carrying at its end a vertical bevel wheel, the teeth of which engage in a horizontal toothed wheel provided with screw threads and attached to the main structure. The rotation of the lever causes the reversing cylinder screwed into the horizontal tooth wheel to rise, and with it the horizontal axis. When using the instrument as a transit circle the upper body should be rigidly connected with the lower main structure by means of four screws.

The vertical axis is mounted downwards so as to keep the upper body as low as possible. It moves within an iron box, and only a quarter of it is cylindrical. The lower portion is conical and terminates in an obtuse cone which can be made to turn in a similar conical bearing in the lift-out cylinder. The latter can by means of an excentric be lifted bodily about 1 mm so as to cause the upper body of the instrument to turn freely on its axis, rendering it thereby available as a theodolite. The diameter of the azimuthal circle is 40 cm. The latter is guarded and divided into 4'. The microscopes read to 0·2", being fitted with micrometer screws, two revolutions of which correspond to 4'. The microscopes are provided with two pairs of webs separated by a distance equal to $1\frac{1}{2}$ times the pitch of the screw so as to facilitate the adjustment and partially eliminate the screw errors. The axis is pierced for field-illumination by means of electric incandescent lamps.

This instrument is the property of the Royal Geodetic Institute at Potsdam.

6. P. Stückrath, Friedenau near Berlin, 11 Albestr.

Maker of Physical Instruments, Fine Balances and Standard Weights.

(See also Section I.)

Pendulum Instrument for Comparative Gravity Measurements. The apparatus consists of a stand, four invariable pendulums having a periodicity of 0·509 second of sidereal time and a bell glass. In addition, the outfit includes a coincidence apparatus for determining the duration and amplitude of the oscillations. The stand is fitted with a solid circular plate which can be levelled by means of three elevating screws. At the centre it is surmounted by a hollow column which is stiffened by four ribs placed at right angles to each other. The base, column and ribs are cast in one piece of gun-metal. To the upper edge of the column a stout brass cross is attached by screws in such a position that its arms bisect the angular spaces between the ribs. Three of these arms carry horizontal agate bearings, upon which the pendulums oscillate on agate knife-edges. A thermometer mounted in the form of a pendulum is suspended from the fourth arm for measuring the temperature of the pendulums. The circumstance that two pendulums swing in one plane and are opposite to each other furnishes a reliable and simple means for determining the synchronic oscillations of the pendulum bearings. The determination of the force of gravity is therefore based exclusively upon the movements of these two bearings, whilst the third bearing is available for observing a controlling pendulum showing irregularities in the movement of the clock. The observations relating to the coincidence with the clock pendulum and the amplitudes are made with the aid of the coincidence apparatus, which is set up in the plane of oscillation of the third pendulum. In the case of this pendulum the observation is therefore direct, whereas for the observation of the other two pendulums two rectangular prisms are attached to the cross. When in use the apparatus is covered with the double-walled bell shade. The latter rests with its ground rim upon the edge of the base plate and thus permits of the air within being rarefied to 0·5 atmosphere so as to diminish the damping effect of the air and also facilitate the exact determination of the temperature of the pendulum, which is of the greatest importance in relative measurements.

The pendulums consist of a lens, pendulum rod and head piece fitted with agate knife edge and mirror. The head piece is shrunk on by heating and subsequent cooling.

The apparatus is the property of the Royal Geodetic Institute at Potsdam.

7. Ludwig Tesdorpf, Stuttgart, 71 Forststr.

Maker of Scientific Instruments of Precision.

Speciality: Astronomical and Surveying Instruments.

(See also Sections IIIb and IV.)

1. **Universal Instrument.** Circles 35×30 cm. Microscope reading 1′. Elbow-telescope fitted with prism and special centreing arrangement. Diameter of objective 54 mm. Telescopic magnifications 54 and 76 diameters. (Focus 65 cm.) With tilting mechanism. The level carrier is made of cast aluminium so as to ensure lightness. The whole is constructed in such a manner as to absolutely obviate strain on individual parts.

2. **Portable Transit Instrument.** Objective 48 mm diameter. With two eyepieces yielding magnifications of 36 and 52 diameters. Finder-circle of 15 cm, diameter divided into $^1/_2$° and reading 1′. Decimal micrometer adjustment. The lower structure is made of cast iron, the level carrier and holder &c. are made of aluminium throughout. The design is such as to completely obviate strains in any of the parts. The 2 to 3 seconds box-level is corrected by a levelling screw of 0·2 mm pitch. The entire rider-level, including the mirror, weighs only 1·250 kg.

3. **Prof. Dr. Schmidt's Trifilar Graviometer,** or seismograph. Changes in the acceleration of gravity, especially those due to the vertical movements of the ground occurring in seismic disturbances, cause a weight with mirror maintained in a state of torsion by a spring and suspended by three threads to rotate about a vertical axis. The amount of rotation can be read by the comparison of two stationary mirrors fitted above and below the movable mirror, or it may be registered photographically.

8. Julius Wanschaff, Berlin S.O., 1 Elisabethufer.

Mathematical and Astronomical Works.

(See also Section I.)

1. **Theodolite for angular measurements of the first order.** Circles 27 cm diameter divided into $^1/_{12}$°. Divisional error 0·2″ to 0·3″. Microscopes magnifying 26 times, fitted with movable cross-line micrometer eyepiece, 1 revolution of the micrometer-screw being 2′, 1 division of the drum = 0·8″.—The telescope has an aperture of 61 mm, focus of 650 mm, three eyepieces magnifying 41, 62 and 72 times respectively.

This instrument is the property of the Royal Survey Office of Berlin. It was made in 1888 and has since frequently been employed for triangulations of the first order.

2. **Visual Zenith Telescope for determining polar altitudes** after the method of Horrebow and Talcott, i. e., for measuring the differences of the zenith distances of two stars culminating respectively in approximately equal altitudes north and south of the zenith. The instrument is mounted in altazimuth form and its circles are merely for the purpose of setting the instrument and surveying the stars, whereas the actual measurement of the zenith differences, which should not exceed 15 to 20 minutes of arc, is made by the eyepiece-micrometer and two mutually controlling Horrebow levels, the carriers of which can be firmly clamped to the telescope. In order to render this connection as solid as possible, especially in opposition to changes of temperature, the usual clamp and micrometer-screw is exclusively used for approximately setting the zenith distance, whilst a screw fitted at the end of the horizontal axis clamps the level carrier firmly against a large annular surface forming the end of the axis.

There are two clamps for the azimuthal movement, one being of the ordinary type for determining errors of position, when the instrument is used like an ordinary universal instrument, the other consisting of two stops attached to the azimuthal circle and adjusted in such a manner as to cause the telescope to pass through the meridian in either position of the circle, without taking a reading each time, by simply clamping the telescope against these stops.

The telescope proper is protected from the influence of radiated heat by being surrounded by another tube which is connected with the telescope at the middle, i. e., near the axis, but otherwise does not touch it.

The high degree of accuracy of which this instrument is capable and, in particular, the comparative absence of systematic errors, renders the zenith telescope eminently adapted for observing the changes of polar altitude. As an instance it may be stated that, apart from its use for a period of several years for observing polar altitudes at Potsdam, it was employed at Honolulu in a series of observations (1891/92), which, concurrently with European and American observations, furnished conclusive proofs of the reality of the oscillation of the axis of the earth.

This design has served as the prototype for a whole series of other, mostly large, instruments constructed by this firm, though modified by the introduction of small improvements in the details.

This instrument is the property of the Royal Geodetic Institute at Potsdam.

3. **Photographic Zenith Telescope,** as suggested by Dr. A. Marcuse. This telescope differs essentially from the preceding instrument merely in that the eyepiece micrometer is replaced by dark-slides for dry plates upon which the two stars under observation are made to trace linear paths, the distance between them being measured by means of a special plate micrometer. This latter operation takes the place of the method of micrometric reading, as adopted in the case of the visual zenith telescope.

This instrument has been constructed for experimental purposes so as to compare the merits of Horrebow's visual and photographic methods. The dimensions are larger in the case of the photographic instruments so as to obtain by virtue of their increased light-gathering power sufficiently distinct tracings of all stars seen in the visual telescope.

The objective, which is made by Steinheil of Munich, is achromatized for actinic rays and yields images, which, though considerably coloured visually, are sufficiently clear for accurately setting the instrument with the aid of an elbow eyepiece, which can be substituted for the plate-holder.

This instrument is the property of the International Geodetic Association Survey Office at Potsdam.

4. **Instrument for Testing large divided circles** and for determining the amount of divisional errors. Two rails are mounted by means of four standards upon a stationary disk. Four microscopes fitted with terrestrial eyepieces and magnifying about 60 times may be moved along and clamped to these rails vertically above any circular graduation not exceeding 42 cm in diameter. The sliding pieces by which the position of the microscopes is altered are provided with a fine adjustment for moving the microscopes at right angles to the radii, so as to accurately adjust the position of the former laterally. Of these rails one is fixed, the other, together with its standards and their connecting piece below the circle, can be turned about the axis of the instrument and clamped in any position, so as to place the microscopes on both rails at any desired angle with respect to each other. These adjustments are made with the aid of a divided circle.

In order that the microscopes may be made to approach each other within the smallest intervals, those mounted upon one of the rails are at right angles to the plane of the divided circle, whereas those sliding on the other rail are inclined outwards. By this means two microscopes can be moved so closely together as to show the same line of graduation in their fields at the same time. The circle which is to be examined, is attached to a revolving disk, fitted with a clamp and fine adjustment. The circles are centred with the aid of a set of centreing disks supplied with the instrument and fitting a cylinder which slips into a strictly central cavity in the main spindle and is there held in position by the constant pressure of a spring. The plane of the graduated circle can be adjusted so as to be absolutely at right angles to the axis of the instrument by means of an ivory-tipped surface gauge which fixes to the rails, and three adjustable elevation plates. Central illumination is produced by a electric incandescent lamp added by the mechanician Fechner, the light of which is thrown upon the graduations by means of movable lenses and mirrors.

This instrument is the property of the Royal Geodetic Institute at Potsdam.

b. Surveying, Mining and Exploring Instruments.

1. Georg Butenschön, Bahrenfeld near Hamburg.

Scientific Instrument Maker.

This establishment undertakes the manufacture of general scientific and, in particular, astronomical and surveying instruments. The specialities of the firm are pocket and simple surveying instruments. Of the latter class a considerable number is exported annually and, consequently, specimens of these only are exhibited.

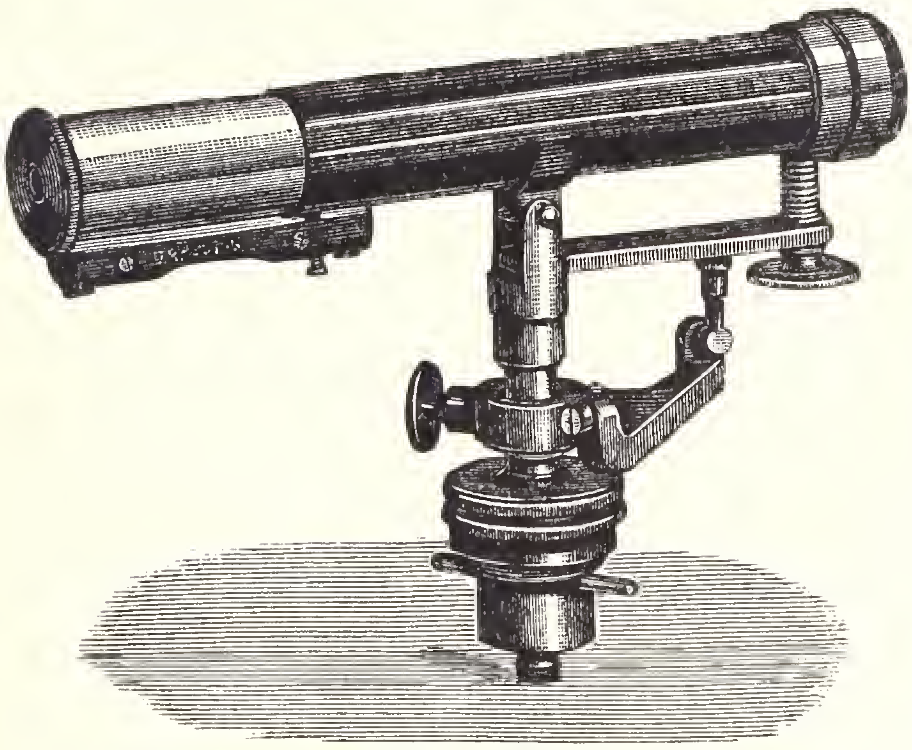


Fig. 1.

Particular attention is called to the Pocket Levels, German patents Nos. 36,795 and 76,668. A special feature of these instruments consists in the fact that the spirit-level, cross-lines and image can be viewed at the same time. Though fitting into a case which is no larger than an ordinary cigar-case, these instruments are exceptionally useful and superior to all others constructed for similar purposes.

Exhibits:

A. Pocket Instruments.

1. **Simple Pocket Level** with ball and socket joint and adjustable foot, telescope magnifying 5 times, adapted for setting off right angles. Fig. 1. (Firm's catalogue No. 3.)

2. **Pocket Level** with ball and socket joint, adjustable foot and micrometer clamping screw. The draw-tube is fitted with rack and pinion. The telescope magnifies 5 times. The horizontal circle is about 75 mm in diameter, divided into $^1/_1{}^\circ$ and reads to 60". Fig. 2. (Firm's catalogue No. 25.)

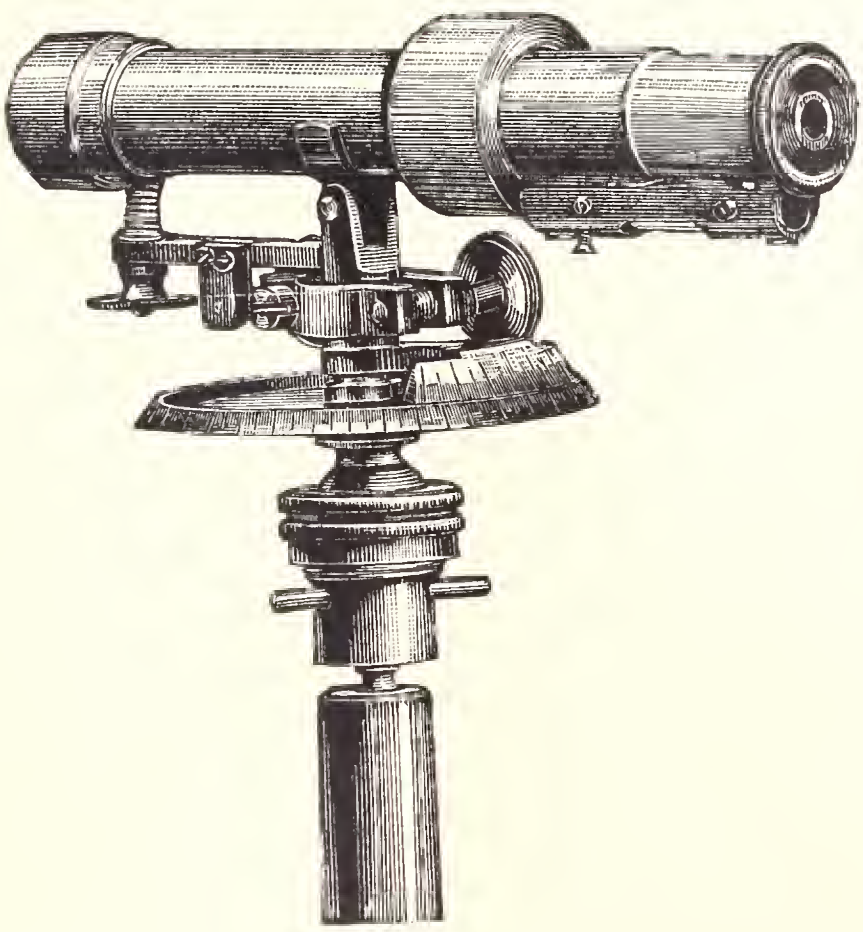


Fig. 2.

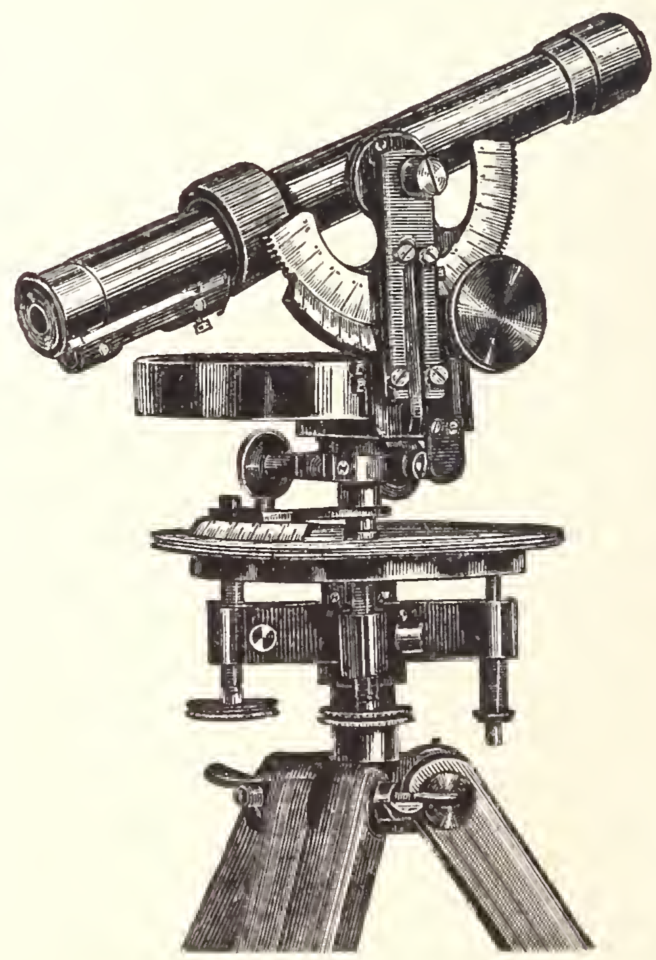


Fig. 3.

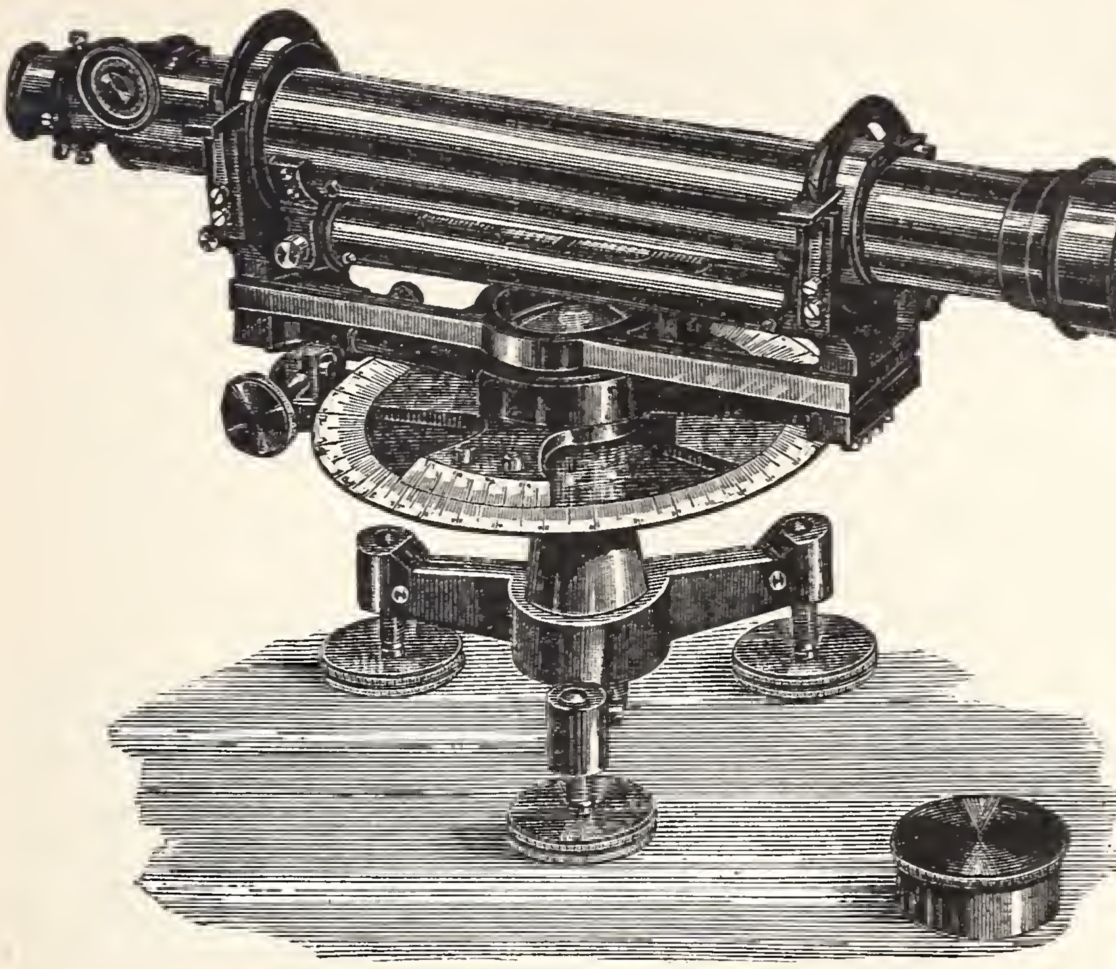


Fig 4

3. **Pocket Theodolite,** fitted with horizontal adjustment and adapted for simple horizontal repetition. The telescope is of the terrestrial type, magnifies 5 times and is fitted with rack and pinion movement. The instrument is fitted with a detachable compass having a needle 70 mm long and graduated into $^1/_1{}^\circ$. The horizontal circle is about 100 mm in diameter and divided into $^1/_1{}^\circ$, reading direct to 60". The altitude arc embraces $\pm 25^\circ$ divided into $^1/_1{}^\circ$, reading direct to 2'. Circular bubble for adjusting the pin, and stand. Fig. 3. (Firm's catalogue No. 38.)

4. **Pocket Theodolite,** similar to No. 3, but with excentrically mounted telescope. Including all necessary mining instruments, such as a circumferenter with reversible sights for fore and back sighting, divided arc and clinometer. (Firm's catalogue No. 57.)

B. Surface Surveying Instruments.

5. **Levels** with reversible telescope about 35 cm long and magnifying 30 times, with spirit-level having a sensitiveness of 10". The horizontal circle, 12.5 cm in diameter, divided into $^1/_2{}^\circ$ and reading to 30", is fitted with a micrometer clamp. The instrument is supplied in a polished case and with a tripod stand. Fig. 4. (Firm's catalogue No. 100 c.)

6. **Repeating Surface Theodolite,** fitted with revolving horizontal circle 15 cm in diameter, divided into $^1/_3{}^\circ$, reading direct to 20"; revolving altitude circle 12.5 cm diameter divided into $^1/_2{}^\circ$, reading direct to 30". A spirit-level having a sensitiveness of 30" is affixed to the alhidada of the altitude circle. The telescope is reversible, has

Fig. 6.

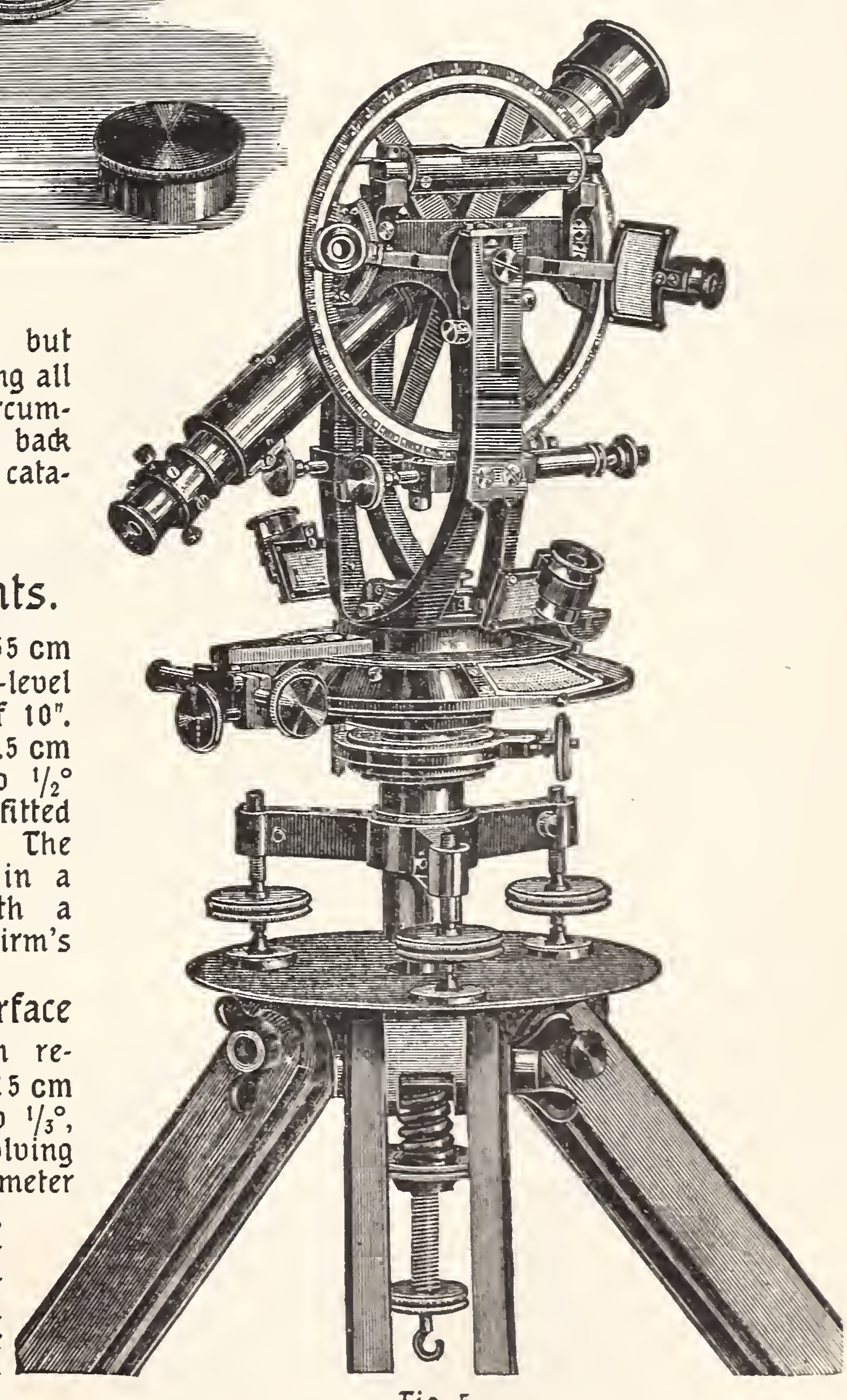


Fig. 5.

an aperture of 30 mm and magnifies about 25 times. The instrument is supplied in a case and with a stand fitted with a metal head. Fig. 5. (Firm's catalogue No. 664 a.)

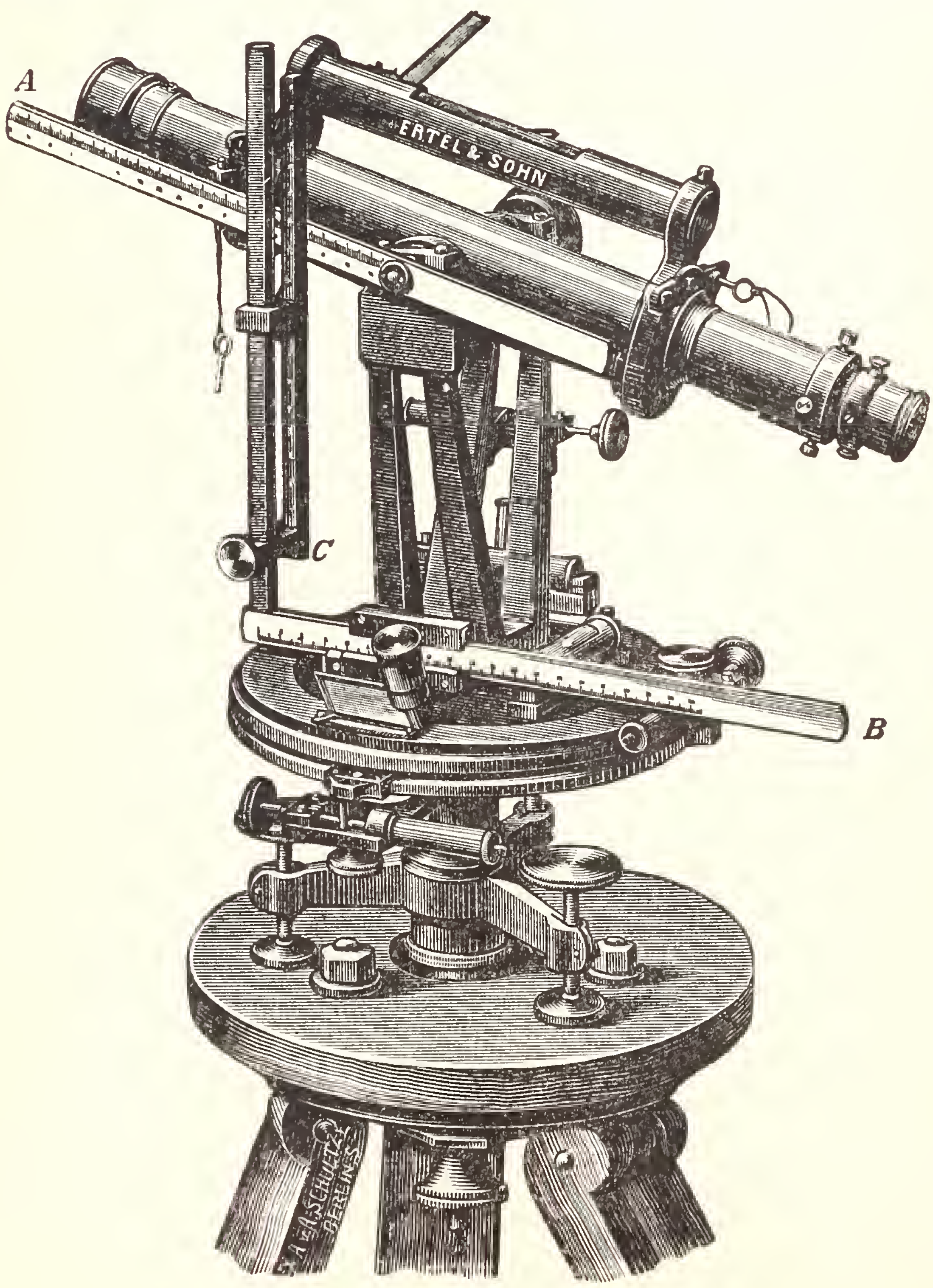
7. **Staff-ranger.** Reg. in Germ. D.R.G.M. No. 56,330, of oxidized brass with sensitive circular bubble. These staff-rangers are supplied in very large numbers in consequence of their being the most convenient means for quickly ranging staves and station-poles being besides available for many other purposes. Fig. 6. (Firm's catalogue No. 181.)

The catalogue of this firm, which may be had free on application, contains in about 200 pages of descriptive and illustrated matter a large selection of instruments. Further information will also be supplied by the Superintendent in charge of the Joint Exhibition of Mechanicians and Opticians.

2. T. Ertel & Sohn, Munich, 27 Louisenstr.

Reichenbach's Mathematical and Mechanical Institute.

1. **Prof. Kreuter's Projection Tacheometer,** as shown in the illustration, for immediately determining the reduced levels and horizontal offsets of any point sighted from the stand-point, for surveying and levelling without calculation. At the same time a universal instrument for engineer's levelling and surveying work. The instrument is equipped with a reversible telescope, fitted with telemetric eye-piece, of 29 mm aperture and 338 mm focus, striding spirit-level and mirror, reading from the eyepiece end. There are two spirit-levels at right angles to each other. Circle (400°) of 162 mm diameter reading direct to 1', and finder divided in 1/2° with pointer. Graduation on silver. The limb and vernier are protected by metal covers fitted with glass plates and are read by movable magnifiers. Weight 8 kg.



2. **Medium-sized Universal Levelling Instrument.** The horizontal circle has a diameter of 140 mm and reads to 30" by two verniers and movable magnifiers. The limb and verniers are protected by a metal casing fitted with glass cover. The altitude arc has a radius of 68 mm and reads to 1' by a double vernier and movable magnifiers. The circles are graduated on silver. The telescope has an aperture of 29 mm, a focus of 338 mm and magnifies 22 times. It is fitted with a telemetric eyepiece with constant 100. Level with mirror, visible from eyepiece end. The instrument has another spirit-level for rapidly setting it in a horizontal position. Weight 4.8 kg.

3. **Fork Level** (small Ertel level without circle), on brass tripod, with telescope having an aperture of 23 mm, a focus of 270 mm and magnifying 20 times. At the side of the supports a pointer serves for expeditiously setting the telescope in a horizontal position. The spirit-level is visible by its mirror from the eyepiece end. Weight 2.3 kg.

4. **Polygonating Theodolite (architect's theodolite, tacheometrical theodolite)** with horizontal circle of 150 mm diameter reading to 30" direct. The limb and verniers are protected by a metal casing fitted with glass plates. The altitude arc has a radius of 70 mm and reads direct to 1' by a vernier. The circles are graduated on silver and read by movable magnifiers. The alhidada has a circular bubble and the frame is fitted at its side with a tube level. The telescope has an aperture of 27 mm and a focus of 244 mm. It is reversible on the objective side and is equipped with a telemetric eye-piece, having a constant of 100. The telescope is fitted with a reversible and detachable spirit-level. Weight 5 kg.

5. **Tacheometrical Compass (field and forest compass)** for topographic surveys, mounted on tripod, and fitted with a telescope having an aperture of 20 mm and a focus of 176 mm and telemetric eyepiece having a constant of 100. The telescope is fitted with rack and pinion. The altitude arc has a radius of 50 mm, it is divided into $1/2°$ on silver and reads by a pointer and magnifier. The striding compass has a sensitive needle 10 cm long, with an excellent central locking arrangement. The compass circle is divided into single degrees. The telescope together with the arc is reversible so as to correct the collimation. A tubular level is at the side. The instrument is provided with horizontal coarse and fine adjustments. Weight $3\frac{1}{2}$ kg.

6. **Röther's Reflecting Circumferenter** (D.R.G.M. No. 51,448), consisting of two movable mirrors, circular bubble and compass. Available as a circumferenter for the graphic reproduction of directions for plane table and topographic surveying, as a compass for measuring horizontal angles and as a protractor for plotting the angles measured with the compass.

7. **Heller's Orientating Instrument** (D.R.G.M. No. 69,969) for supplementing and correcting positions on maps and plans, also for the graphic survey of small tracts of land. The compass is 8 cm in diameter. Circular level. The telescope magnifies 8 times and is fitted with a telemetrical eyepiece, having a constant of 100.

8. **Hydrometric Propeller,** indicating by differential wheels 1,200 revolutions, reading to $1/2$ revolution. The three propeller blades are made of aluminium and have an external diameter of 13 cm and a width of 28 mm. There is no rudder and the apparatus is fitted with a very convenient form of release.

9. **Certificate** relating to a hydrometric propeller tested by the Hydrometric Testing Department of the Royal Polytechnic School, of Munich, showing the coefficients and a graphic representation of the equation expressing the velocity of the water current.

10. **Drawing of the Motor Car** employed for these tests. The car has been built at the carriage works of Jos. Rathgeber, of Munich, from data supplied by Prof. Dr. M. Schmidt.

3. G. Falter & Sohn, Munich, 33 Kreuzstr.

Mechanical Institute.

A. Frank's Hydrometric Tube serves the purpose of determining, by one single observation, the mean velocity of the vertical component of water currents. Its construction is based upon the method of determining the mean hydraulic pressure. The latter is produced in a perforated tube having the holes placed against the current and causes the column of water to rise within the tube to a certain height above the water-level according to the mean dynamic pressure. The reading is taken by means of a manometer indicating meter-seconds.

The instrument is available for all kinds of hydraulic measurements in canals, streams and rivers, and has already been used for a number of years by various administrative bodies and technical colleges in Russia, Austria, Italy and Germany.

Further information will also be given on application.

4. Otto Fennel Söhne, Cassel, 8 Wörthstr.

Manufacturers of Surveying Instruments.

1. **Repeating Theodolite** without altitude circle, with limb 12 cm in diameter, cross-levels on the alhidada, reversible and transit telescope and striding level on the telescope spindle. Fig. 1.

This model is made in two sizes, with limbs 10 and 20 cm in diameter.

2. **Repeating Mining Theodolite** with horizontal circle with limb of 10 cm internal diameter, altitude circle 8 cm diameter, cross-levels on the alhidada, reversible and transit telescope, striding level, compass to rest upon the horizontal axis and field illumination through the spindle.

This model is made in two sizes, with limbs 10 and 20 cm in diameter. Fig. 2.

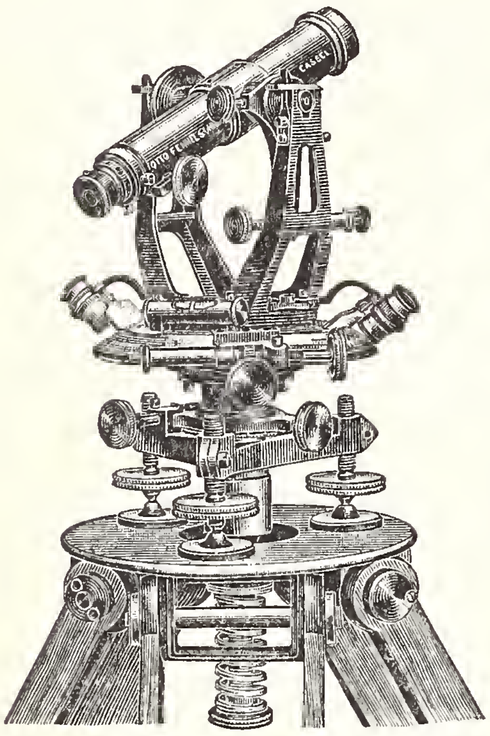


Fig. 1.

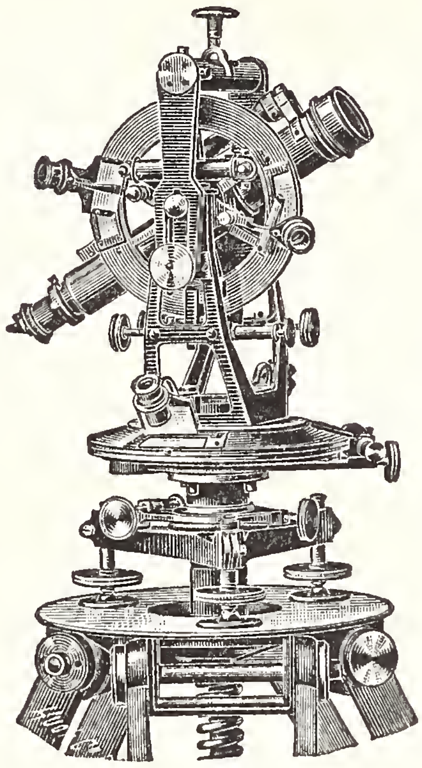


Fig. 2.

3. **A. Fennel's Orientating Instrument,** for the magnetic orientation of polygonal sides in mines.

This instrument consists of a mining theodolite without altitude circle having a limb of 13.5 cm in diameter, upon which is placed a Fennel orientating magnetometer.

This magnetometer represents the first instance where the usual long magnet needle has been replaced by a bell magnet suspended by a quartz fibre. This method ensures a degree of sensitiveness which exceeds by far that obtainable with magnet needles oscillating on pivots.

The instrument exhibited is the property of the Royal Prussian Mining Academy at Berlin. A detailed description of the instrument, including illustrations and directions for adjusting and treating it, will be found in the "Mittheilungen aus dem Markscheiderwesen," Neue Folge. Heft 1. 1899. Published by Craz & Gerlach, Freiburg, Saxony. Comprehensive tests have been published by Mr. Bimler, of the Royal Mining Survey, in the Zeitschrift f. praktische Geologie. No. 7. 1896. Published by Julius Springer, Berlin.

4. **Wagner-Fennel's Tacheometer.** This instrument consists of a repeating theodolite, having a horizontal circle 15.5 cm in diameter, a telescope fitted with telemetrical cross wires and a projector, which takes the place of the altitude circle of the usual forms of tacheometers. Fig. 3.

In all tacheometers provided with an altitude circle, the horizontal distance and elevation of the foot of the tacheometer staff has to be calculated with the aid of a slide-rule or tables with respect

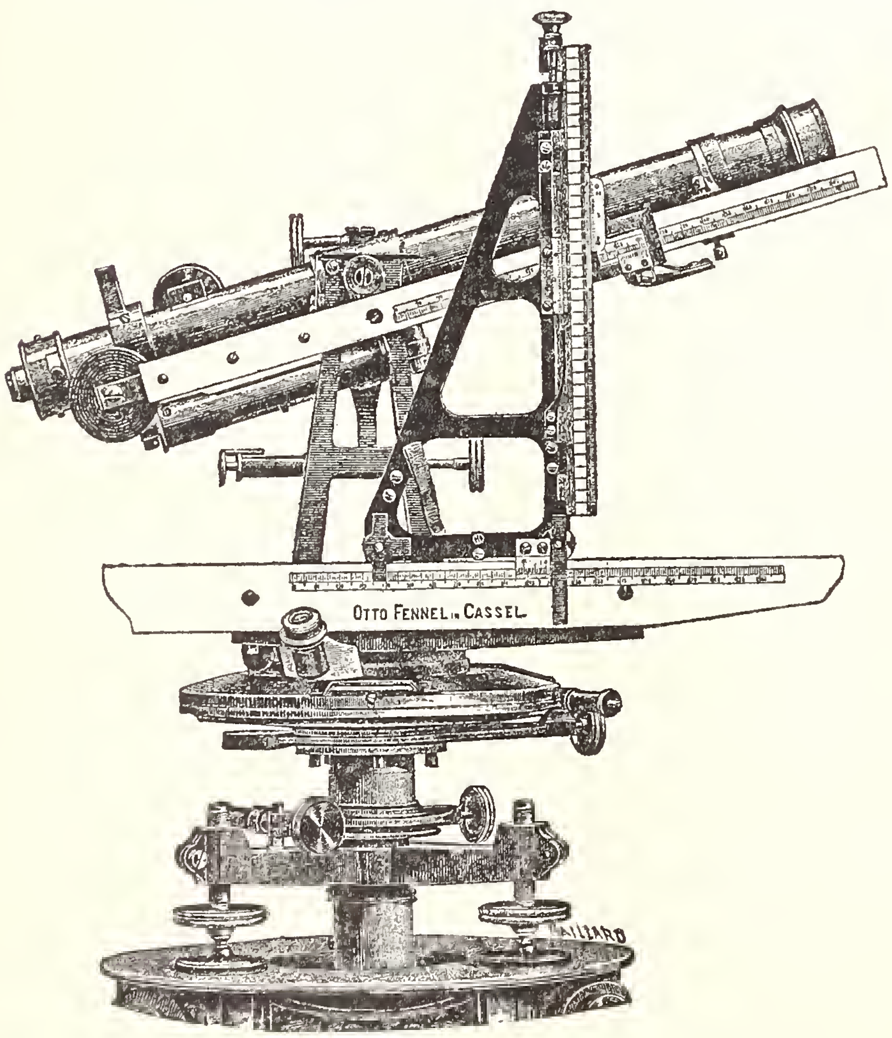


Fig. 3.

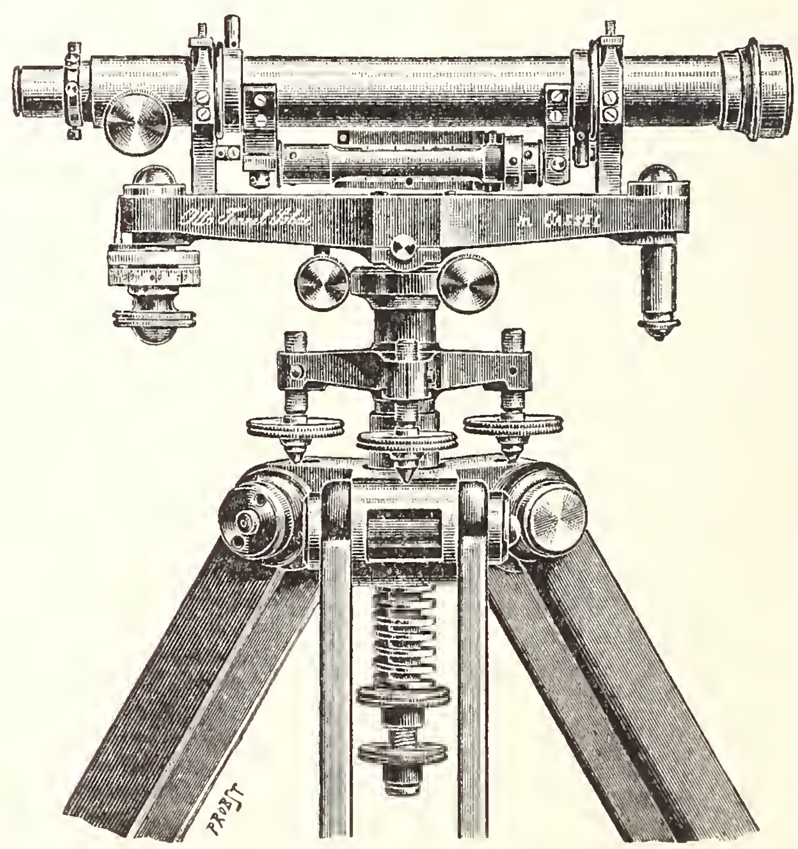


Fig. 4.

to the centre of the instrument from data supplied by the staff reading and the angular altitude. The Wagner-Fennel tacheometer entirely obviates the laborious process of looking up tables and calculation, as the horizontal distances and sea-levels at the foot of the staves are given direct by the projector.

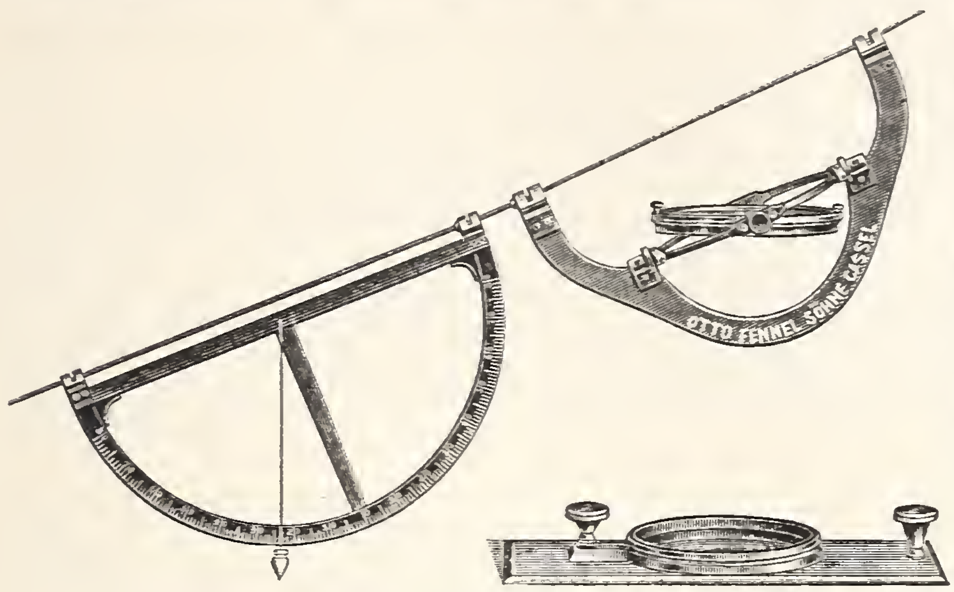


Fig. 5.

These tacheometers are fully described in an illustrated work entitled:—"Die Wagner-Fennel'schen Tachymeter des mathematisch-mechanischen Instituts von Otto Fennel in Cassel. Cassel 1886," and "Supplements I and II, 1891." (Price Marks 5.) This book discusses the theory of the projector and supplies full directions for the adjustment of the instrument, also numerous testimonials supported by numerical data. The French edition of this book, the price of which is Marks 3, bears the title:—"Les Tachéomètres Wagner-Fennel de l'Institut mathématique-mécanique Otto Fennel à Cassel, Allemagne, 1887. Paris, Gauthier-Villars, Imprimeur-Libraire, Quai des Augustins 55."

5. **Level** with rotating telescope, reversible spirit-level and tilting screw with divided drum. Fig. 4.

6. **Mining Compass**, Cassel pattern, consisting of a vertical sector with compass and arc, in leather case, and circumferenter in case. Fig. 5. The magnet needle is mounted with its edge upwards and is 7.5 cm long.

5. Max Hildebrand, late August Lingke & Co., Freiberg (Saxony).

Makers of Astronomical, Surveying, Mining, Metallurgical and other Instruments.
Established 1791.

(See also Section IIIa.)

a. Astronomical Instruments for Explorers.

1. **Universal Travelling Theodolite** with altitude circle of 14 cm diameter and horizontal circle of 12 cm diameter. The verniers are read off without parallax by powerful microscope lenses. The excentric telescope of 25 cm focus and 35 mm aperture serves for the observation of the eclipses of Jupiter's moons.

2. **Hildebrand's Universal Travelling Theodolite,** fitted with altitude circle $9\frac{1}{2}$ cm in diameter reading 30" by verniers, horizontal circle 8 cm in diameter reading 60". The excentric telescope has a focus of 12 cm and an aperture of 20 mm and is provided with artificial illumination. It is fitted with a telemetric screw. Various magnetic instruments may be mounted on the theodolite. This theodolite has, in a large number of expeditions, both in the polar and tropical regions, proved its value as a conveniently and safely portable instrument of considerable precision and adaptability. Its weight is 1.6 kg. The instrument exhibited is the property of the German Admiralty.

b. Surveying Instruments.

1. **Screw Microscope Theodolite** with a revolving horizontal circle 16 cm in diameter, each division of the microscope drum reading 5". The verniers of the altitude circle read 20". The telescope has a focus of 32 cm and an aperture of 32 mm. The instrument exhibited is the property of the German Admiralty.

2. **Repeating Theodolite with estimating microscope.** Horizontal circle 18 cm in diameter, numbered microscopically and divided in $1/6°$. The instrument is provided with a microscope, by means

of which each interval of the limb is divided into 10 minutes and each minute may be divided into 10 or even 20 parts by estimation (6" or 3" respectively). The mean error is ±2". The telescope is mounted for central transit on its trunnions, it has a focus of 30 cm and an aperture of 32 mm. This instrument is the property of the Royal Agricultural College of Berlin.

3. **Tachymetrical Theodolite,** fitted with round compass and stadiometer screw. The verniers of the 16 cm horizontal circle read 20", and those of the altitude circle 30".

4. **Hildebrand's Clino-tacheometer,** designed from suggestions by Prof. Ch. A. Vogler, and embodying the fundamental principles of Hogrewe and Sanguet. The telescope is directed upon a vertical scale staff. Its guide rod is displaced 1 mm by the tilting-screw, the clamping arm and telescope follow the movement before and after which the reading is taken. The interval a on the staff and the reading b taken on the guide rod (b being an integer) give the sighting distance = 100 a and the sighting elevation = ab + lower reading on the staff. The point of intersection of the guide rod and the clamping arm describes a strictly rectilinear path on both parts. The horizontal circle is divided into $\frac{1}{6}°$ and the alhidada is provided with two verniers and an auxiliary index. The instrument has also an orientating compass. This instrument is the property of the Royal Agricultural College of Berlin.

5. **Repeating Field Theodolite,** fitted with a 12 cm horizontal circle, reading to 30" by verniers, and an altitude circle reading to 60" by verniers. The telescope, which has a focus of 21 cm and an aperture of 25 mm, is mounted centrically in transit fashion and is fitted with a distance thread and reversible spirit-level.

6. **Hildebrand's Telescopic Plumbing Apparatus,** for accurately placing the centres of surveying instruments above station points. The body of the small telescope serves as the axis of rotation of the instrument and is adjustable vertically by means of intersecting spirit-levels. The objective mount is spherical, and fits into the cylindrical opening of a centreing plate upon which the apparatus is placed by its tripod. The process of centreing is identical with that of the old Freiberg method originated by Hildebrand for mining theodolites and their signalling appliances. It is equally well adapted for field surveying with the aid of signals.

7. **Nagel and Hildebrand's Levelling Instrument** for measurements of the highest degree of precision, fitted with telescope of 44 cm focus and 41 mm aperture. The position of the spirit-level is seen without parallax from the eye-piece end with the aid of a magnifier, mirror and markings inscribed upon the glass. The upper body is tilted on its horizontal axis by means of an elevating screw.

8. **Levelling Instrument** with reversible level for precise work, constructed upon the same principle as the preceding instrument but simpler in detail. The focal length of the telescope is 36 cm only.

c. Mining Instruments.

(Speciality of this firm for more than a century.)

1. **Mining Theodolite** adapted for repetition, having a horizontal circle of 16 cm reading 10" by verniers and an altitude circle reading 30". Telescope of 27 cm focus and 27 mm aperture. Between the standards of the telescope axis the instrument is fitted with a box compass the needle ends of which can be observed magnified 10 times in the telescope eyepiece and an objective prism hidden in the telescope spindle.

2. **Pocket Mining Theodolite,** having, in addition to the centric telescope, an excentric telescope to screw on. The horizontal circle is 8 cm in diameter, the altitude circle 6 cm, both reading to 60".

3. **Circumferenter** with Hildebrand's sight-vanes, which owing to their unchangeable nature are steadily superseding the old folding vanes.

6. A. Meissner, Berlin W., 65 Friedrichstr.

1. **Prof. R. Doergens's Universal Travelling Instrument.** Circle 8 cm diameter divided into $\frac{1}{2}°$ reading to 1' by verniers. The telescope has a focus of 12 cm, magnifies 8 times and is fitted with telemetrical eyepiece. The vertical axis is adjusted by means of a circular bubble, and oblong spirit-levels with two bubble centres are mounted parallel to the telescope. A compass is permanently attached to the graduated circle, as in Moinot's tacheometer. The divided circle can be used in two positions by means of adjustable sleeves. When the circle is horizontal the instrument

is available for measuring horizontal angles and magnetic azimuths, also vertical angles not exceeding 30°; when it is vertical the instrument can be used for measuring vertical angles within ±90° and for levelling. In either position the instrument is completely balanced. The exhibits illustrate both positions of this instrument.

Both instruments are the property of the Royal Technical College at Charlottenburg. The same instrument has been used successfully by Dr. Stuhlmann in Africa, by Dr. von Drygalski in Greenland and by Mr. Scholz, Government architect, in Italy.

2. **Tacheometer with fixed vertical spindle,** which, being mounted upon the head-stock by a ball and socket joint, can be rotated as well as moved sideways and admits of the theodolite being rapidly set up centrally and with its alhidada spindle vertical. The instrument is provided with the fittings for Reichenbach's telemetric method with altitude circle, as well as those for measuring distances and elevations by means of a clinometer scale and screw. A tubular compass is attached to the side of the azimuthal circle. This tacheometer is exhibited on its own stand.

The instrument is the property of the Geodetic Collection of the Royal Agricultural College of Berlin.

7. Randhagen, Mechanician, Hanover.

1. **Jordan's Tacheometer** with celluloid altitude arc. Circular tacheometer with filar telemeter. Double altitude arc of 12.5 cm radius; graduated into $^1/_6$° on celluloid and reading to 1' by single index lines. The horizontal circle has a diameter of 14.5 cm and is divided in $^1/_3$° reading by verniers. The objective has an aperture of 34 mm, a focal length of 48.5 cm, Huyghenian eyepieces and magnifies 34 times. The instrument is fitted with a striding compass, a tube spirit-level attached to the altitude arc, and a box-level mounted on the vertical spindle (see Zeitschr. f. Vermessungswesen, 1899. p. 50).

2. **Jordan's Protractor** with celluloid arc. Alhidada protractor, for ensuring accurate centreing, with revolving excentric slide-ruler to move along the T-square. The protractor circle has a radius of 5 cm and is made of celluloid. The slide-ruler is adjustable by a graduated arc for mapping out the magnetic deviation (see Zeitschr. f. Vermessungswesen, 1899. p. 135).

Both instruments belong to the Geometric Collection of the Polytechnical College of Hannover.

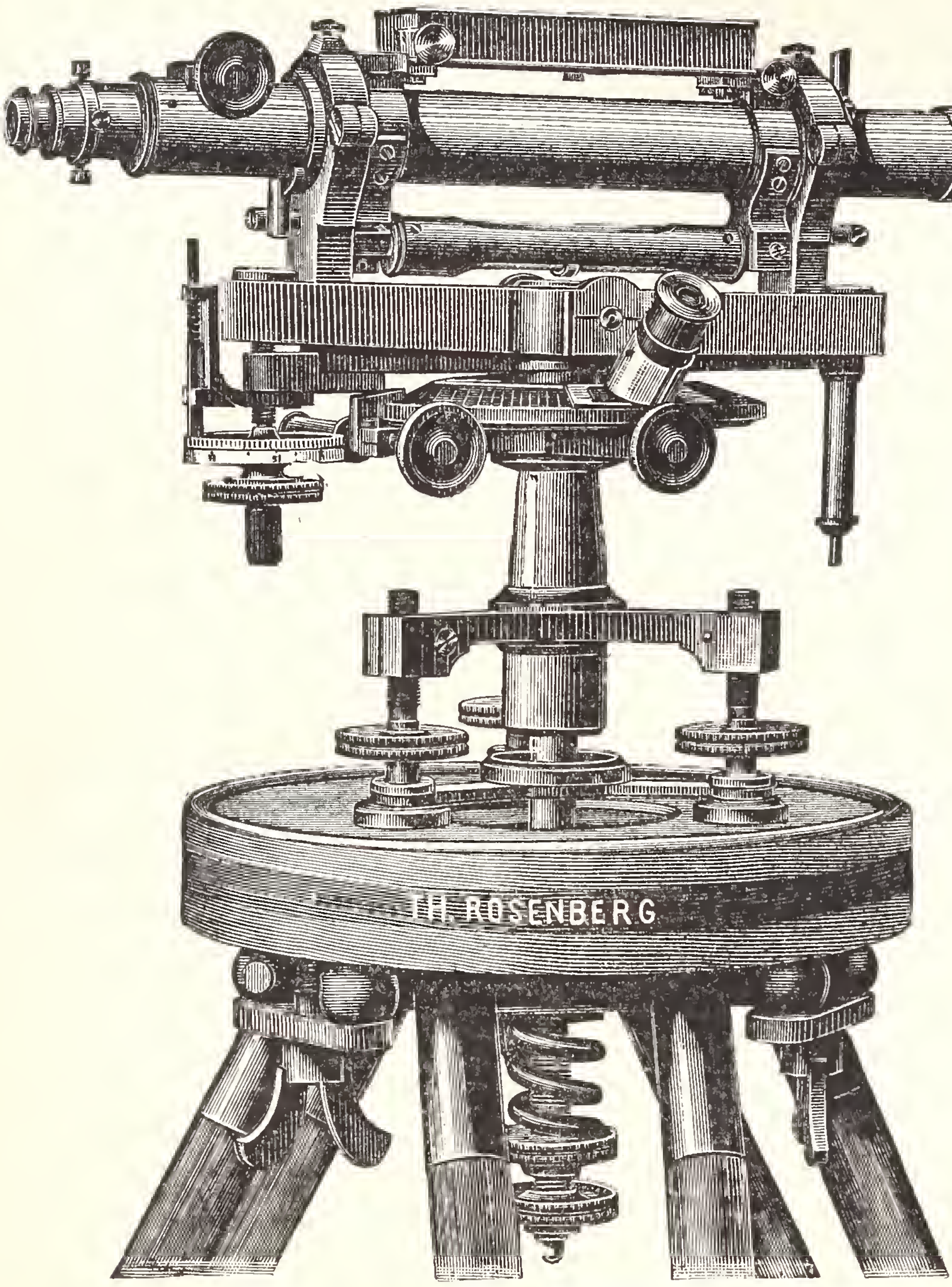
8. Th. Rosenberg, Berlin N., 95 Chausseestr.

Mathematical Instrument Maker.

1. **Station Pole Bubble,** easily attached and removed. To facilitate the vertical holding of the staves while sighting and fixing. It is also adapted for use with the staff of the optical square or the cross-staff.

2. **Repeating Theodolite with Hogrewe's Clinometer-screw** for occasional use, when measuring distances and elevations after Corber and Sickler's method. The azimuthal circle is covered, its limb has a diameter of 12 cm and is divided on silver into $^1/_3$° reading 30" by verniers and movable magnifiers. The telescope is reversible, mounted on transit axis and fitted with clamp and micrometer movement, the latter being in the form of a clinometer-screw with drum and scale. The object glass has a focus of 200 mm and magnifies 20 diameters. There is a striding level above the transit axis and a circular bubble between the frames.

3. **Tacheometrical Theodolite.** The covered azimuthal circle has a limb 14 cm in diameter and is divided on silver into $^1/_3$° reading to 20" by verniers and movable magnifiers. The telescope is mounted on transit axis and fitted with clamp and fine adjustment; it has a focus of 250 mm and magnifies 24 diameters by means of an orthoscopic eyepiece fitted with telemetrical cross-lines. The altitude circle has a covered limb divided on silver into $^1/_3$° reading to 30" by verniers and movable magnifiers. An alhidada bubble with fine adjustment serves for accurately setting the vernier index. A striding level is situated above the transit axis of the telescope and a levelling bubble is permanently attached to the latter, also there is an adjustable circular bubble within the frames. An oblong orientating compass can be placed upon the transit axis.



No. 4. Tacheometer level with clinometer-screw.

4. **Tacheometer Level with Hogrewe's Clinometer-screw,** for measuring directions, distances and elevations after Lorber and Sickler's method. Adapted for moderately inclined sighting. The telescope, mounted in adjustable rings, has a focus of 325 mm and magnifies 28 times by means of an orthoscopic eyepiece, showing the divisions of the staff distinctly at 250 m. The telescope is fitted with a reversible bubble reading to 20″ from the eyepiece end by means of a mirror. The alhidada bears a circular bubble. The azimuthal circle is covered and divided on silver into $^1/_2$° reading to 1′ by movable magnifiers and two verniers, one of which (A) is fitted with an auxiliary pointer to obviate gross errors. An orientating compass can, without trouble, be affixed above the telescope.

5. **Tacheometric Plane Table Theodolite,** as suggested by Ch. A. Vogler. The elevational angles are rendered independent of the inclination of the table by the bubble alhidada, the horizontal angles by a cross-level, the axis of rotation of which constitutes the straight-edge. The telescope is of the transit type, has a focus of 300 mm and magnifies 25 times by an orthoscopic eye-piece fitted with 3 telemetric cross wires. The altitude arcs are divided on silver into $^1/_6$° reading to 30″ by verniers, which can be accurately set by an alhidada bubble, one of them having in addition fitted to it an auxiliary pointer, so as to obviate gross errors. The cross bubble mounted upon the straight-edge, is parallel to the transit axis and can be set horizontally by means of a set-screw with large milled head. An orientating compass can be attached to the straight-edge. The equipment of this instrument includes a small striding level to place above the transit axis for adjusting and a circular bubble for the plane table.

6. **Simple Level fitted with Hogrewe's Clinometer-screw,** for levelling station-points when the horizontal line of vision meets the ground or passes above the station-pole, also for occasional telemetry.—The telescope has a focus of 325 mm and magnifies 28 times and shows the divisions on the staff at a distance of 200 m. A bubble is permanently affixed to the telescope reading to 20″. The instrument is fitted with a circular bubble for plumbing the main spindle.

7. **Station-pointer,** being a fully divided circle with a fixed and two movable arms with radial straight edges, for plotting down station-points when the directions of three fixed points are known. For topographic and coast survey.

8. **Bauernfeind and Vogler's Prismatic Squares** of the best form as to field of view, range of rotation and reflecting capacity, ground and polished by Hensoldt. Adapted for setting off angles of 90° and 180°, 45°, 90° and 180°, by double and quadruple reflection within the prisms.

Instruments Nos. 2, 4, 5, 7 and 8 are the property of the Geodetic Collection of the Royal Agricultural College of Berlin.

Price-lists may be had free on application.

9. Karl Scheurer (Firma C. Sickler), Karlsruhe, Baden.

Court Mechanician and Optician.

1. Koch-Scheurer's Plane Table Tacheometer and Roller Slider. This tacheometer is adapted for surveying operations generally requiring the use of a level, theodolite and plane table. The instrument can be employed in two ways. Fig. 1 shows it fitted with the plane table in a central position, i. e., arranged as a tacheometer for the survey of moderately large areas (scale 1:500 to 1:1,000). The tripod of the instrument is surmounted by the central fixed plane table A. Above this table a disk B fitted with a scale C is rigidly attached to the azimuth alhidada so as to turn together with the telescope. The drawing paper which usually takes the form of a pierced sheet of tracing paper is placed between these two disks. Upon this all the points sighted should be pricked off, and the elevations measured by the slider should be noted. Fig. 2 shows the other method of using the instrument, in which the plane table occupies an excentric position. So arranged the tacheometer is adapted for topographic surveys (scales from 1:5,000 to 1:2,500). D is a straight-edge to which is fitted a toothed disk E, and F is a fixed plate above E. G is a scale which can be connected with the disk E. The movements of the telescope are transmitted to the scale G by the geared disks H and J. The process of plotting is here the same as with the centrally fixed table.

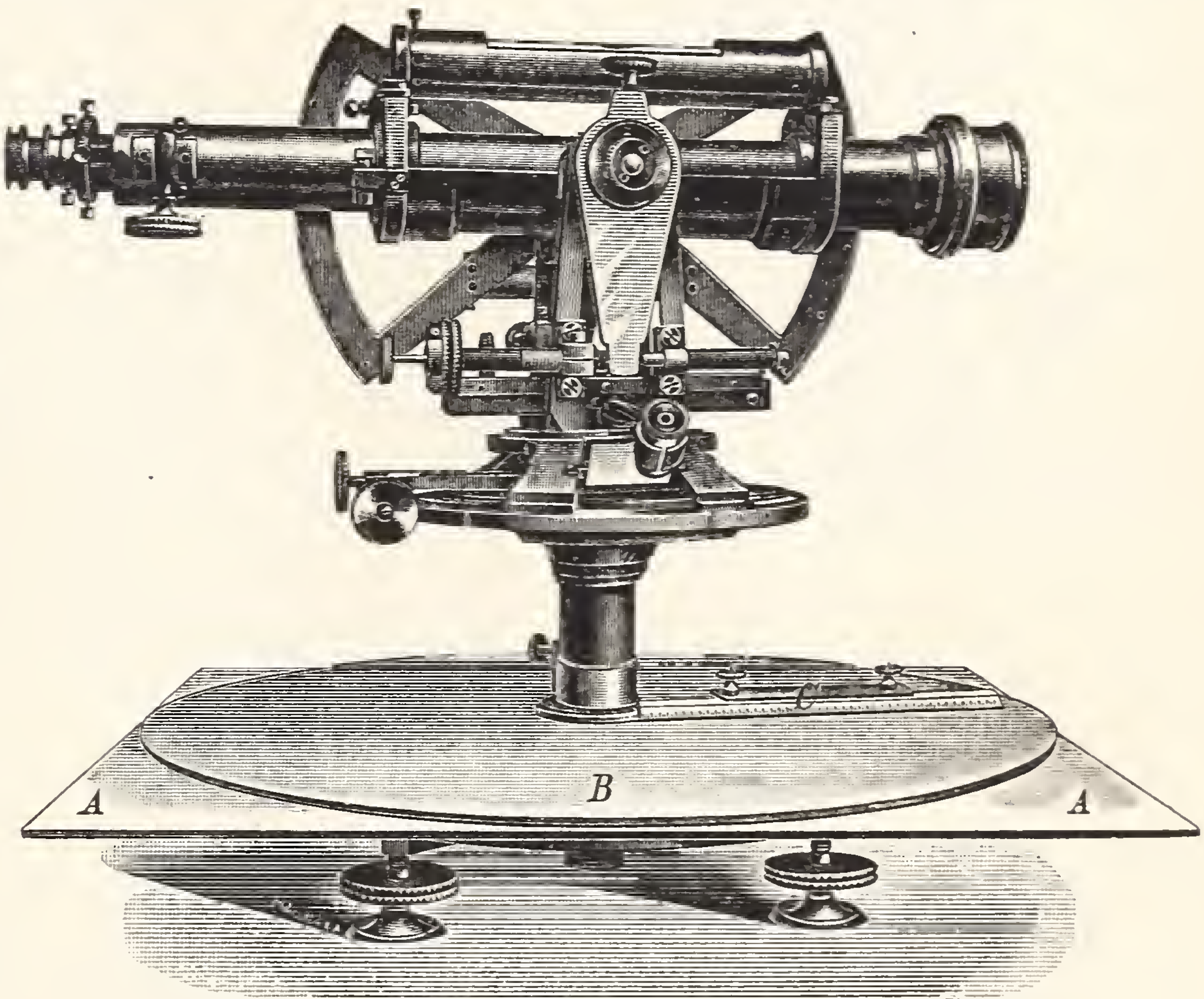


Fig. 1.

The absolute levels are determined by the cylindrical tacheometer slider. Each point is sighted at those angles for which the corresponding tacheometrical scales are marked upon the roller. The apparatus is sufficiently convenient for use in the field and can be set in the same time that is required to read the scales and distances at the instrument. The result is accordingly found immediately.

Under moderately favourable conditions 600 points can be observed, computed and plotted within eight working hours.

2. Repeating Theodolite having an azimuthal circle of 18 cm, an altitude circle of 13 cm, both circles being protected by glass covers. The telescope has a magnifying power of 30 diameters and is fitted with a telemetrical eyepiece reading 1:100. It is mounted on a transit frame and can be reversed. The altitude circle is fitted with a vernier bubble, and a striding level and compass fit loosely upon the horizontal spindle.

3. Small Universal or Travelling Theodolite. The horizontal circle is adapted for repetition, and, like the altitude circle, has a diameter of 12 cm. The telescope is reversible and mounted on a transit frame. The equipment includes a striding level, vernier bubbles on the altitude circle, telemetrical eyepiece reading 1:100, field illumination through the horizontal axis, an "elbow" eyepiece with sun-glass and a tubular compass below the horizontal circle.

4. Level with Sickler's Percentage Clinometer-screw for measuring slopes and distances. The telescope is reversible and can be rotated, the levelling bubble is finely adjusted by means of a tangential screw and its position is shown by a mirror. The tangential screw is fitted with a drum divided

into 100 parts. The distance of the clinometer-screw from the horizontal tilting axis is exactly equal to 500 turns of the screw. Each turn is shown on a divided index. Five turns correspond to a fall of 1 per cent, one turn is therefore $^1/_5$ per cent, $^1/_{100}$ of a turn $^1/_{500}$ per cent, and $^1/_{1000}$ per cent can be read without difficulty since the half divisions of the drum can be estimated with the greatest ease.

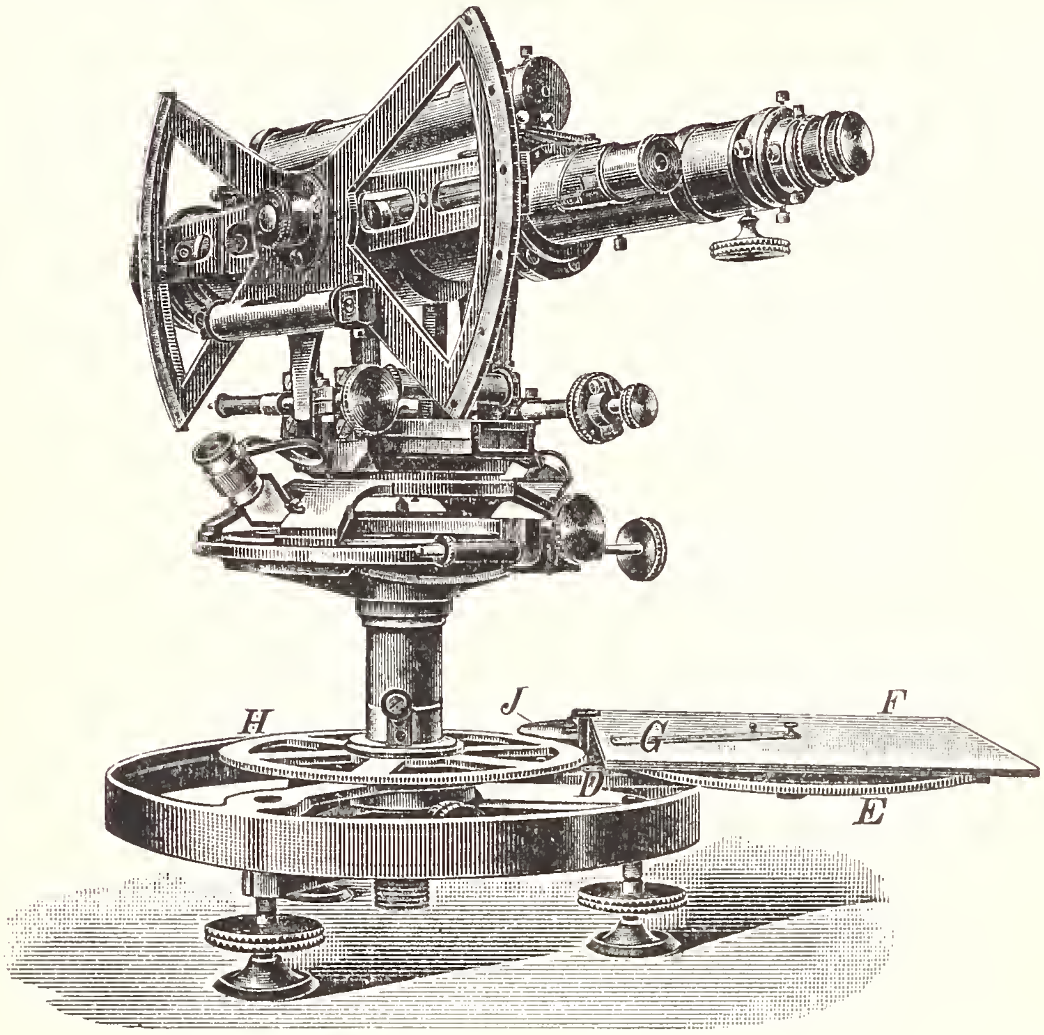


Fig. 2.

5. **Percentage Clinometer,** of original design, being a pendulum instrument, consisting of a rectangular frame which, being suspended by a ball and socket joint and fitted below with a plumb-bob, always assumes a vertical position. The frame is provided with two slots within which two diopters can be moved and adjusted by means of graduations.

Each of these divisions amounts to 0.005 of the distance between the diopters. The rise and fall can therefore by its means be read directly in percentages. The diopters are adapted for fore and back sighting.

6. **Mayer's Clinometer,** for measuring slopes and angles, being a pendulum instrument fitted with lens diopter without magnifying power and adapted for fore and back sights. The instrument is very small and handy and can easily be carried in the pocket.

7. **Various Etched Glass Plates** for the computation of areas.

10. Mich. Sendtner, Munich, 22 Schillerstr.

Mechanical and Technical Works.

Small Theodolite with Attachable Compass. This instrument is easily centred. By a coupling of special construction the instrument can be quickly adjusted for use in the horizontal position. It is adapted for use as a theodolite and as a level. The instrument is easily tested and adjusted before being used without the aid of special means. The spirit-level can, when desired, be replaced by a compass.

11. Wilh. Spoerhase, late C. Staudinger & Co., Giessen (Hesse).

Physical and Mechanical Works.

(See also Section I.)

Measuring Instruments for Forestry. Telescopic and dioptric instruments for forest and road survey, reconnoitring, levelling, &c. Tree height and thickness gauges. Simple measuring and registering instruments of the latest form for the survey of timber. Wimmenauer and Spoerhase's circular counting gauge.

Any of the appliances required in practical forestry are kept in stock or supplied.

12. W. Stiegel, Cassel.

Scientific Instrument Maker. Speciality: Astronomical, Geodetic, Surveying and Mining Instruments.

1. **Mining Theodolite,** reading by verniers and fitted at the bottom of the telescope frames with a detachable oblong compass. The position of the needle ends is seen without parallax through the telescope eyepiece. Firm's catalogue No. 249.

2. **Mining Theodolite** with detachable compass fitting the telescope spindle. The telescope is mounted outside the frame so as to render the instrument available for plumbing pits. Firm's catalogue Nos. 244 and 244 O.

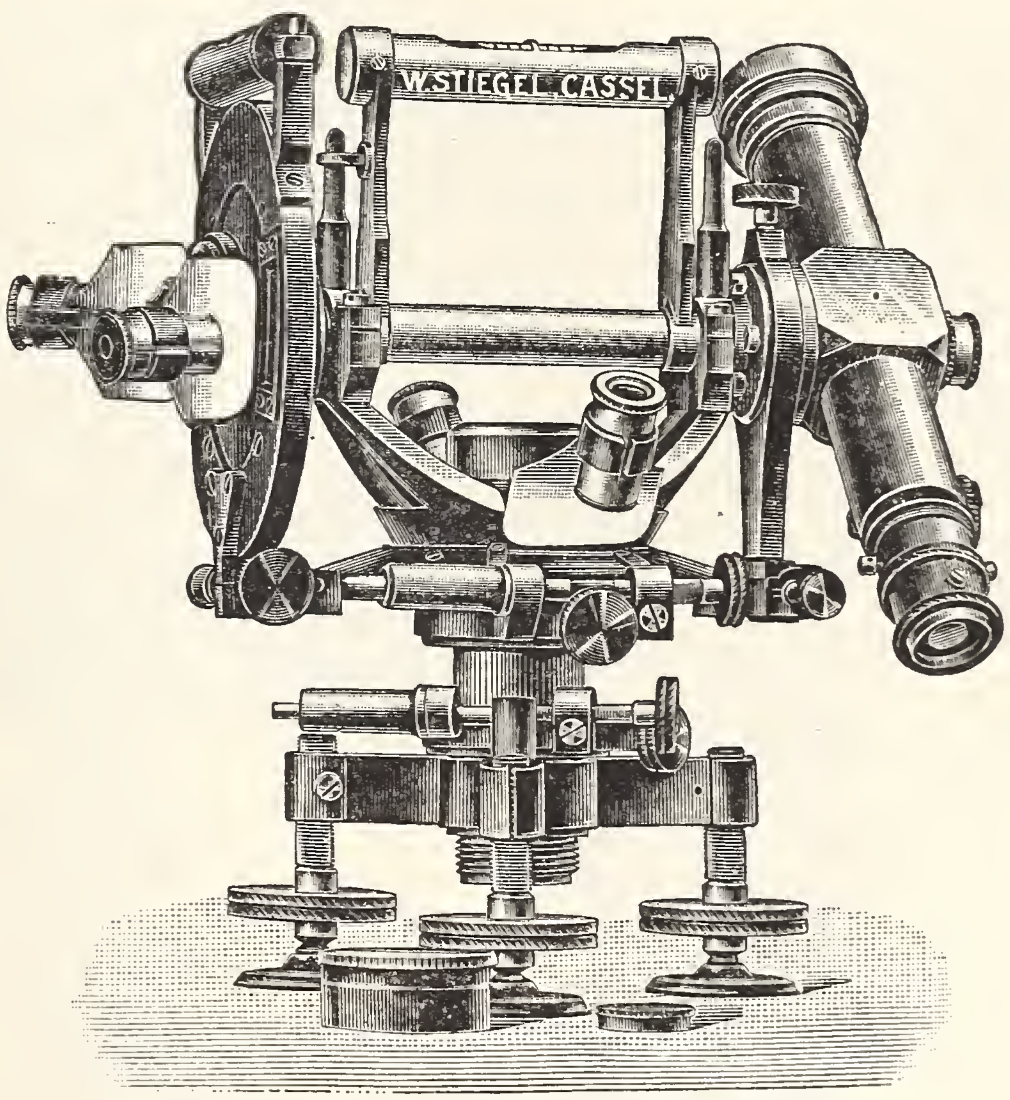


Fig. 1.

Travelling Theodolite. Circles 16 cm in diameter. Firm's catalogue No. 253.

3. **Simple Theodolite** reading by verniers. The circles are divided on argentan. Firm's catalogue No. 52.

4. **Travelling Theodolite,** smallest pattern, available for repetition, with outside telescope and detachable bubble. Firm's catalogue No. 253.

5. **Mining Compass** with detachable compass proper. Divisions on argentan. Firm's catalogue No. 292.

6. **Level** with reversible bubble. The latter is permanently attached but can be turned round the axis of the telescope. The instrument can be tilted so as to correct the bubble.

7. Figure Punching Machine, of original design, for appropriately punching figures on divided circles of all kinds, &c., also for inscribing firms' names. This machine is 50 cm in diameter and is provided with two sets of teeth. The original divisions are available for numbering in terms of the sexagesimal and centesimal system.

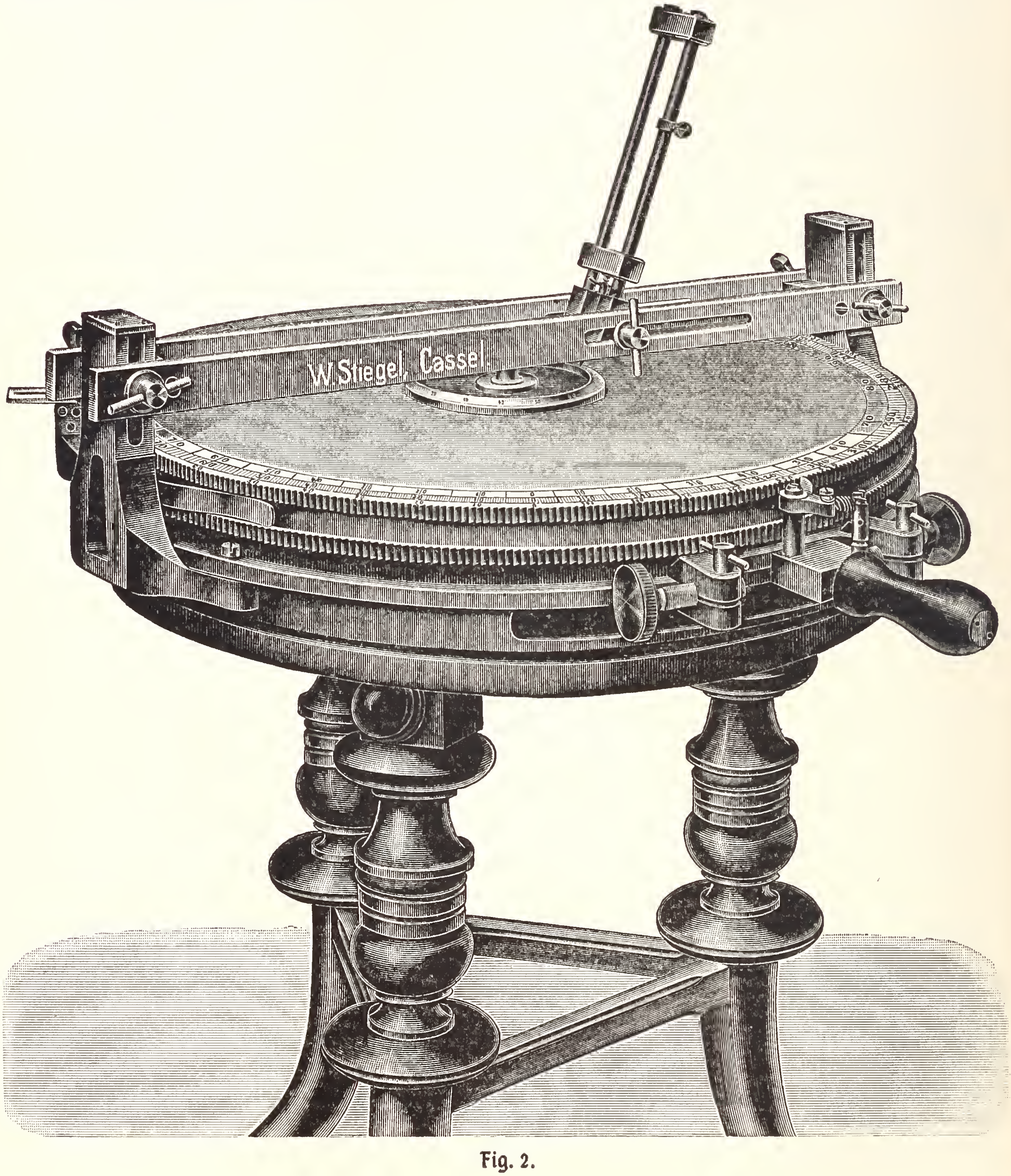


Fig. 2.

A detailed price-list may be obtained on application to the Superintendent in charge of the Joint Exhibition of Mechanicians and Opticians.

13. Ludwig Tesdorpf, Stuttgart, 71 Forststr.

Maker of Scientific Instruments of Precision.

Speciality: Astronomical and Surveying Instruments.

(See also Sections IIIa and IV.)

1. **Universal Instrument.** Both circles have an internal opening of 17 cm diameter. They are graduated into $1/6°$, and 6" can be estimated by reading microscopes. The telescope magnifies 36 times.

2. **Small Universal Instrument** adapted for repetition. Horizontal circle 12 cm diameter divided on silver into $1/6°$, reading to 6" by two screw-microscopes. The objective has a particularly large aperture and magnifies 24 times. The vertical circle is divided into $1/3°$ and reads to 20". The instrument is provided with a telemetric eyepiece. A telescope compass is fitted below the horizontal circle.

3. **Compass Theodolite** adapted for repetition. Horizontal circle of 20 cm diameter divided into $1/6°$, reading to 10". Altitude circle 17 cm diameter. In addition, the edge is divided into $1/2°$ to facilitate the localization of stars (for surveying purposes the instrument has a percentage scale).
The correcting screws of the striding spirit-level serve at the same time as supports on the telescope axis and have fitted to their ends rounded cylinders of agate so as to obviate oxidation of the points of contact. The absence of any screws acting in opposition to each other removes the possibility of straining the instrument while adjusting it.
The compass is mounted between the standards. The magnetic needle is 120 mm long.

4. **Compass Theodolite** adapted for repetition. Circles of 12 cm and 10 cm diameter, reading to 20" and 1' respectively. The telescope spindle is perforated as in the preceding instrument. The cross-lines are illuminated by a lantern. An elbow eyepiece is provided for zenith observations.

5. **Tachymeter Theodolite** adapted for repetition, with compass and circumferenter. Horizontal circle 12 cm diameter, altitude circle 10 cm, divided on silver into $1/2°$, reading to 1'. The telescope magnifies 24 times and is adapted for measuring distances.

6. **Small Tachymeter Theodolite** without means for repetition. Circles 10 and 8 cm respectively, graduated on silver into $1/2°$, reading to 1'. The telescope magnifies 20 times. This instrument is specially adapted for survey in forests and mountainous districts. It is provided with a distance measuring scale on glass.

7. **Large Theodolite** adapted for repetition, having a horizontal circle of 17 cm diameter, divided into $1/6°$, reading to 10". The vertical circle has a diameter of 12 cm and is divided on silver into $1/3°$, reading to 20". The telescope magnifies 30 times.

8. **Smallest Travelling Theodolite.** Both circles have an internal diameter of 7 cm and are divided on silver into $1/2°$, reading to 1'. The telescope is excentric, magnifies 12 times and is provided with vertical micrometer adjustment. The spirit-level is reversible. The instrument is fitted with an eyepiece prism provided with two sun-glasses and has an eyepiece telemeter on glass with vertical lines for star observations.
Note. The base of the compass is perforated and covered by a glass disk so as to render the spirit-level mounted below conveniently accessible to observation. The weight of the instrument, including its case, is 1.900 kg.

9. **C. Wagner's Tacheographometer** with adjustable filar telemeter. Both the projection of obliquely measured distances upon the horizontal plane and the elevational differences of the point sighted reduced to the centre of the instrument can be read off directly without any further calculation by means of the distance-rule attached to the telescope, two graduated rules attached to the frame and the base-plate and a movable projection triangle, the method being based upon the tachymetric formula $E = D \cdot \cos^2 \alpha$.
The distances, having the anallactic difference corrected, can be directly mapped out on paper with the aid of the movable needle apparatus which travels in conformity with the projection triangle.
The altitudes are also reduced to the constant instrumental level of 1.5 m before being read off. The declination compass fitted to the frame is adjustable with respect to the true meridian and can be detached so as to render it available for setting out on the drawing table.

10. **Tilting Theodolite** of the latest construction, having a scale 60 cm long capable of parallel adjustment. The telescope is mounted for transit. The altitude arc has a limb of 17 cm aperture and is divided into $1/3°$, reading to 20" direct; the verniers are fitted with special spirit-level adjustment. The spirit-level is reversible. The telescope magnifies 24 or 36 times. The distance scale is etched on glass.

11. Under-structure of Surveying Table, for No. 10, adapted for tables of any size.

12. Large Levelling Instrument for exact work at considerable distances, R. Wagner's system. The telescope magnifies 60 times. The spirit-level, which has a sensitiveness of 5 to 6", is reversible and protected from the influences of temperature by a metal cover. The position of the bubble can be observed directly from the eyepiece end by reflection and a lateral magnifying lens.

13. Levelling Instrument for exact work. The telescope is mounted on four carneol prisms and turns on its longitudinal axis. It has fitted to its side an accurately ground 6" reversible spirit-level. Simple rotation through 180°, position I (spirit-level on the left) and position II (spirit-level on the right), and exact adjustment of the bubble in either position, suffice to furnish very exact figures even with imperfectly rectified instruments. If, for example, during transport the spirit-level changes its position with respect to the axis of collimation, the values of δ as read off the staves in positions I and II may be found to be respectively greater or smaller, but since the final value depends upon their arithmetical mean those values are of no consequence. It should, however, be noted that when taking successive readings in positions I and II the telescope should be turned carefully.

14. R. Wagner's Patent Levelling Instrument, similar to No. 12, but with telescope magnifying only 24 times. The telescope is likewise mounted upon four carneol prisms. Reversible spirit-level sensitive to 10".

15. R. Wagner's Patent Pocket Levelling Instrument, with telescope magnifying 18 times, in case.

16. R. Wagner's Patent Pocket Levelling Instrument, with telescope magnifying 12 times, in case.

17. Dr. Schlichter's Photographic Camera for geographic localization. The method consists of photographing in rapid succession the moon together with one of the distinctly visible planets or a fixed star of the first and second magnitude situated near the moon's orbit. For that purpose the dark-slides are arranged in such a way that six photographs can be taken in rapid succession with a Zeiss Anastigmat Series II a, of 205 mm focus. Each exposure is taken with a slit 10 mm wide. The distances are measured by a glass micrometer 10 cm long, divided into 0.5 mm.

18. Orientation Instrument for orientating the position of mines. The horizontal circle has an internal diameter of 15 cm, divided into $^1/_3$° and reading to 20". The declination compass is mounted in an accurately central position and can be drawn out; it has a magnetic needle 15 cm long pivoted on a ruby cap. By means of a lens fitting in front of the object-glass the telescope can be temporarily converted into a microscope, with the aid of which the divisions at the end of the magnetic needle can be sighted.

The lateral auxiliary telescope serves for nadir and zenith observations. The telescope spindle is perforated and fitted with a lantern.

19. Percentage Clinometer (Diopter-Instrument), with altitude arc, which, in addition to the percentage scale, is divided into $^1/_1$°, reading to 10' by a vernier.

20. Prof. Dr. Decher's Prismatic Drum for setting off circular arcs.

21. Liniometer, with three rollers, for determining the lengths of lines of any form (curves, spirals, serpentines, &c.).

22. Liniometer, with seven rollers.

23. Protractor, for fixing on the plan a point which has been localized with respect to three given points by triangulation.

Note. The manipulation of the instrument is rendered more convenient by two interchangeable centres, one being fitted with a needle and pen, the other with cross-lines ruled on glass.

24. Prof. Dr. Hammer's Parallel Ruler for rapidly plotting down points.

25. Hydrometric Vane, specially constructed for determinations requiring a high degree of accuracy. The apparatus is fitted with an electrical indicator, giving one signal at the end of every 50 revolutions, and is entirely made of nickeled brass with the exception of the vane and spindle, which are made entirely of aluminium. The ends of the spindle are fitted with agate points running in conical agate cups, so as to reduce the coefficient of friction to a minimum.

14. Max Wolz, Bonn-on-the-Rhine.

Scientific Instrument Maker.

(See also Section Vb.)

1. **Reinhertz Tacheometer** with cylindrical altitude circle so designed as to enable the observer to take all his readings from a fixed position. Both circles are divided into $^1/_3{}^\circ$, reading by verniers to 1'. The azimuthal circle has, in addition, two verniers reading to 20". The telescope is fitted with telemetrical wires and a telemeter-screw reading 1:100.

2. **Large Reinhertz Level** with clinometer-screw and double wires for adjusting the divisions. The telescope has an aperture of 42 mm, focus of 42 cm and magnifies 30 or 40 times. The bubble is effectively screened from the effects of heat and reads 8" per division. The clinometer-screw is protected from dust. The spindle and its bearing are made of hard steel and the entire under-structure is designed with a view to solidity.

3. **Repeating Theodolite** for demonstration and practice, to illustrate all existing errors. The azimuthal circle is divided into $^1/_1{}^\circ$ and can easily be thrown out of centre: the same applies to the indices. The diopter-telescope and diaphragm can be displaced laterally. The altitude circle is divided into whole degrees and is available for horizontal and zenith angles. All the spirit-levels are deeply curved and graduated and numbered throughout. In addition to a striding level, the instrument has bubbles attached to the telescope, the alhidada of the altitude circle and the telescope frame. A circular bubble is fitted to the lower frame. In addition, there is in the middle of the frame a compass with movable centre. The tripod is fitted with plates for setting the instrument up anywhere without risk of injuring it.

4. **Level** for demonstration and practice, to illustrate instrumental errors. The telescope is reversible and fitted with movable objective and ocular diopters. By means of a movable collar the adjustment is disturbed in a manner which is strikingly shown by the removable bubble. The telescope is, in addition, fitted with a fixed spirit-level. The bubbles are deeply curved and graduated throughout. The telescope bearings can be raised and lowered. A reversible and optically equipped telescope is supplied with the instrument, so as to practically demonstrate the optical errors. This, as well as a large circular bubble, are attachable to the frame of the level.

5. **Brandis's Hypsometer**, with graduations in degrees and percentage, as used by foresters for measuring the height of trees, by surveyors for reducing hypotenusal to horizontal readings, for calculating differences of elevation, setting off road lines, &c. Convenient tables are supplied with these instruments. The object, diopter and graduations are seen concurrently. The reading is accurate within $^1/_{10}{}^\circ$. The instrument is very convenient and, being well encased, eminently adapted for tropical climates.

All these instruments are the property of the Royal Agricultural College at Poppelsdorf near Bonn.

C. Nautical Instruments.

1. Carl Bamberg, Friedenau near Berlin, 39/41 Kaiserallee.

Scientific Instrument Maker and Optician.

Established 1871.

Telegraphic address: Bamberg-Friedenau.—Telephone: Friedenau No. 14.

(See also Sections IIIa and IV.)

1. **Deviation Magnetometer with Rottok's Vertical Force Balance**, for comparative determinations of the horizontal and vertical components of the earth's magnetic intensity, especially in conjunction with nautical deviation work. The instrument is likewise adapted for measuring the mag-

netic declination and dip. The vertical force balance supplied with the instrument serves for measuring the vertical magnetic lines of forces and, especially, for compensating the errors due to vertical induction in mariners' compasses.

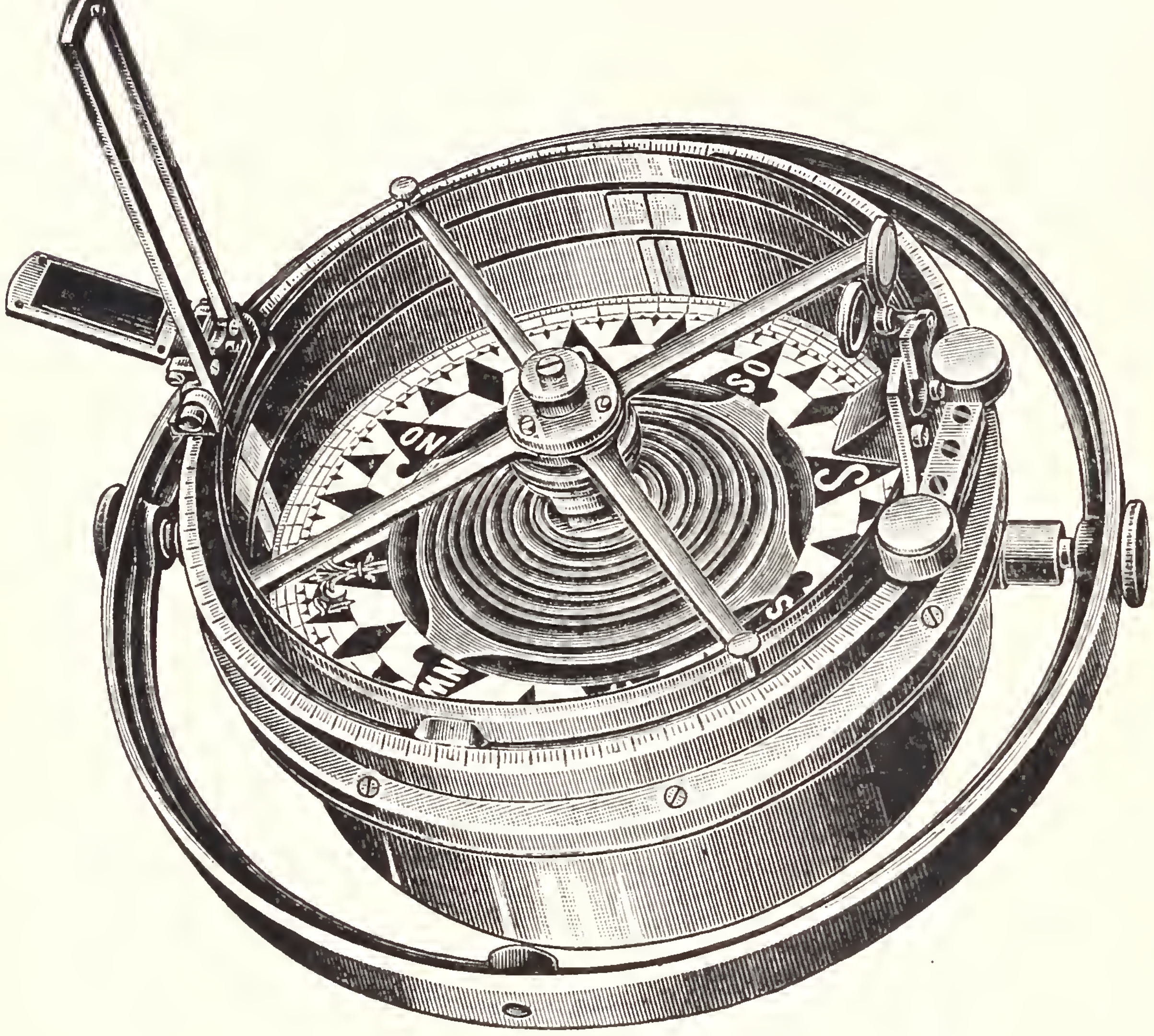


Fig. 1.

2. Large Floating Compass, Fig. 1, with 4 internal steering points and elastic double bottom, rose with magnet consisting of 24 laminae, enamelled card 196 mm in diameter, divided into degrees at the edge and figured both for ordinary and prismatic reading. The compass is balanced and suspended in roller bearings within the helmet.

3. Diopter Attachment, for the above, with telescope, shadow pin and large ocular diopter, divided inwards into degrees and reading by opposite indices. The sighting telescope has an aperture of 21 mm, 100 mm focus, magnifies 6 times, embraces an angle of 2°; it is fitted with a vertical wire and is mounted upon standards fitting the diopter.

4. Compensating Compass, Fig. 2, fitted with a set of soft iron cores situated in the horizontal plane of the rose magnet needles and grouped in a circle or ellipse round the latter, so as to increase the directive force and correct the oblique quadrantal error. By altering the position of the compass box, this compass is available for neutralizing the constant deviation. The compass box and rose are similar to those of the floating compasses.

5. Ordinary Boat's Compass with rose 118 mm in diameter, two layers of double laminated magnets, gimbals and folding stand.

6. Diopter Attachment for the above, divided into degrees and reading by two opposite pointers.

7. Binnacle with sphere carriers and correcting spheres consisting of brass column 300 mm in diameter, compensators having 2 magnet-carriers with 4 C-magnets on each, a lower circle with indices and double clamp, vertical induction magnet sleeve to raise and lower by chain, helmet with door, night-helmet ring with set-screws, gun-metal foot with 3 screw-down bolts and plates.

8. Oval Revolving Night-helmet for the Binnacle, with 2 petroleum lanterns. Head-light and front and

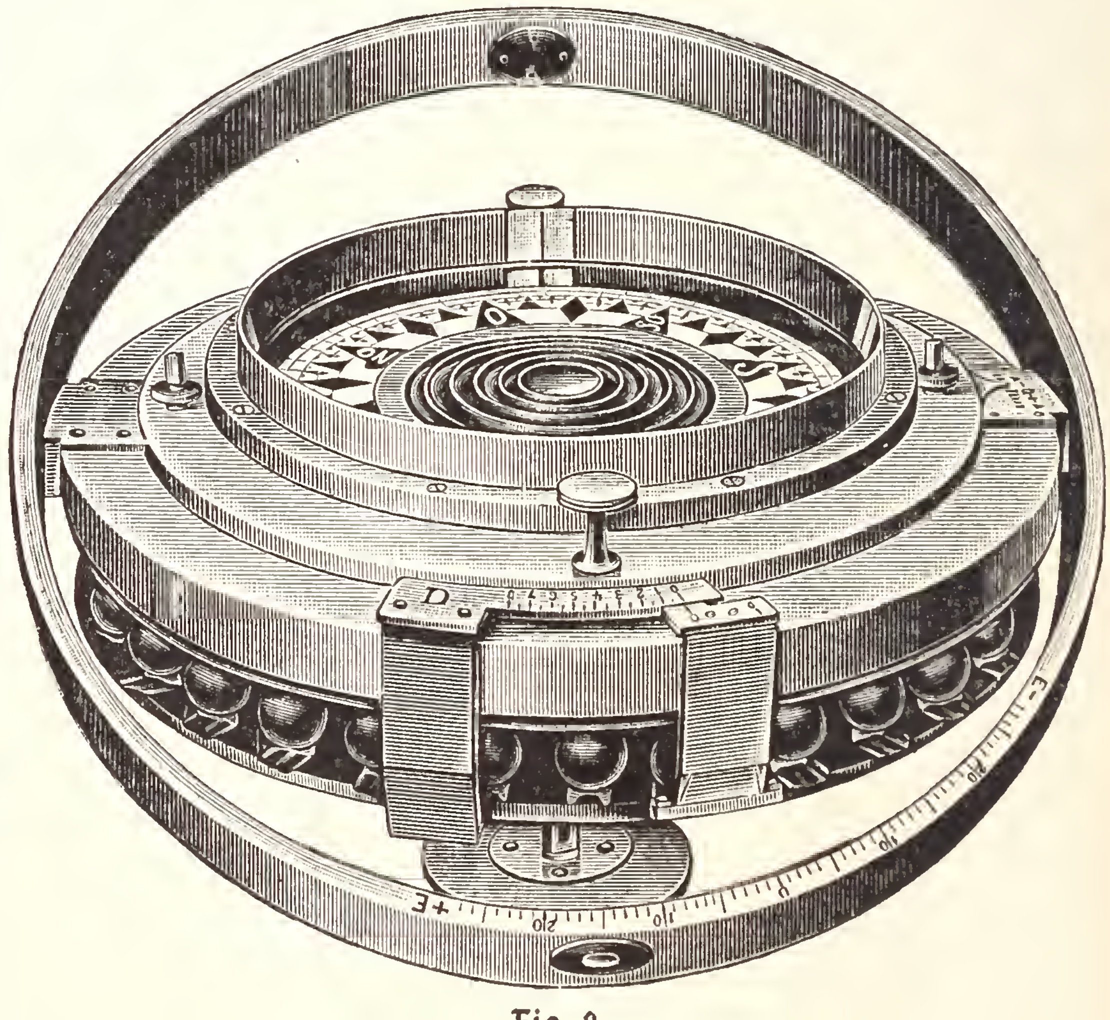


Fig. 2.

back door fitted with screening plates, also large door with shut-off screen, lower ring fitted with rollers and clamping screw.

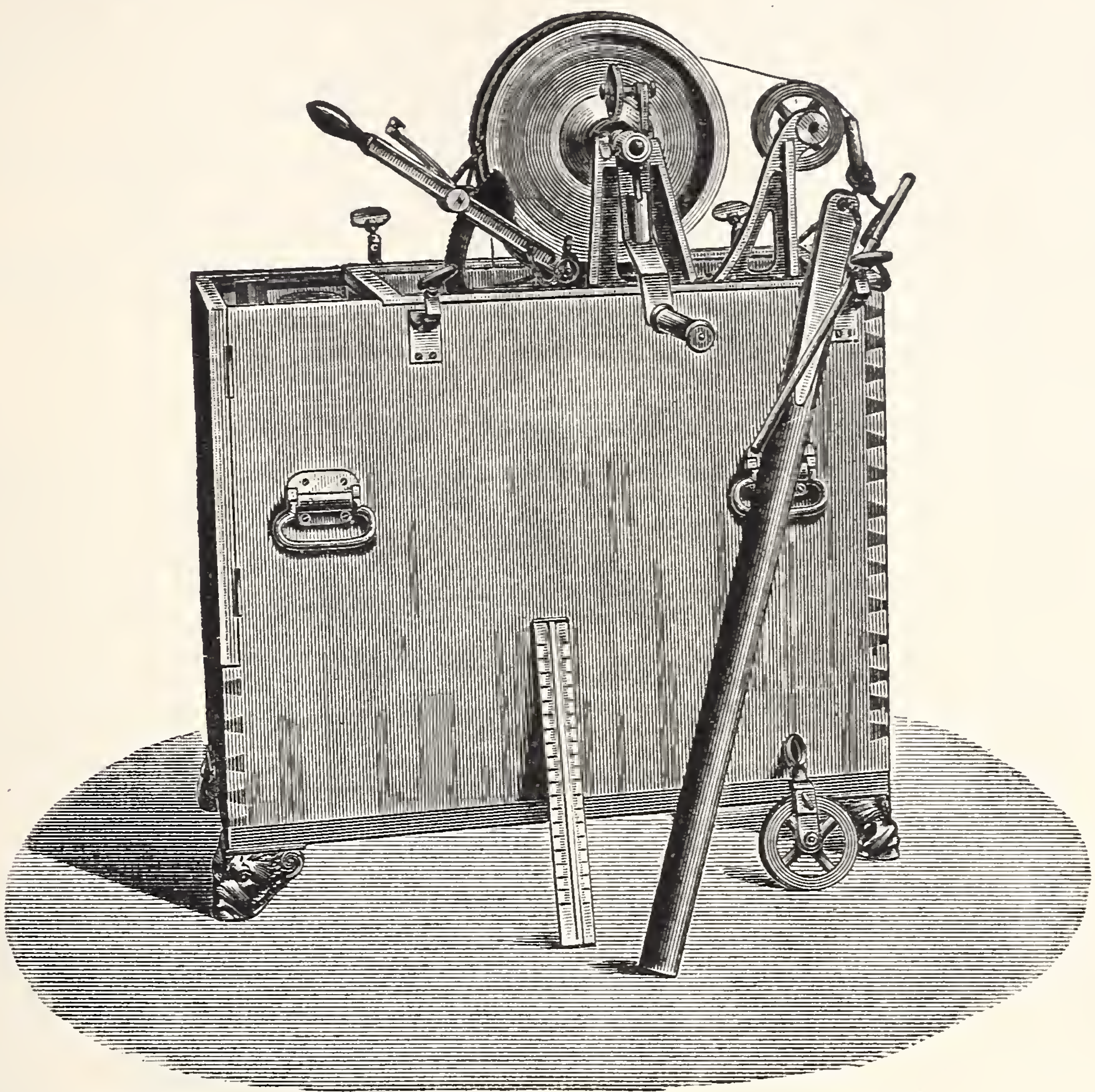


Fig. 3.

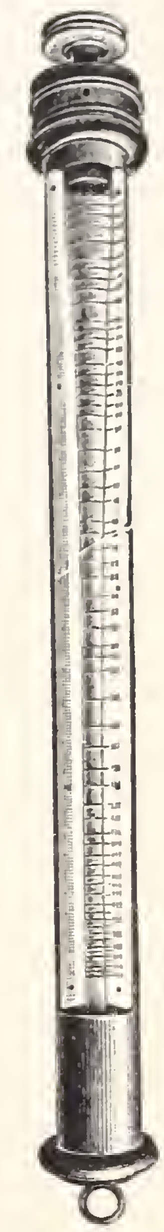


Fig. 4.

9. **Sounding Machine** with protecting hood of galvanized iron, in teak-wood box lined with zinc and fitted with gun-metal feet and corner bindings, with separate receptacle for all accessories, counter and dial, malleable steel cranks, calipers, gun-metal pulley block, 2 scales, 4 sheaths, 4 galvanized iron rings, zinc tins for glass tubes, tin for tallow, lime vessel, vaseline pot, 4 iron sinkers, 100 prepared glass tubes in case und 600 m of tested wire.

10. **Pneumatic Depth Recorder** with sheath, for depths not exceeding 200 m.

2. H. Haecke, Berlin S.O., 124 Wrangelstr.

Optician and Philosophical Instrument Maker.

1. Large Reflecting Prismatic Circle.
2. Small Reflecting Prismatic Circle.
3. Sextant.
4. Octant.
5. Mercurial Horizon fitted with hood.

6. Ferk's Parallel Protractor.

This protractor solves in an efficient and expedient manner any of the usual problems of navigation by the chart, dispenses with the chart compass and saves the chart itself from wear and tear. This universal instrument for mariners, cartographers and constructors comprises within one instrument the functions of the following appliances:—Parallel ruler, set-off squares, double protractor, alhidada protractor, compass card divided into 1/4 and 1/8 points, T-square, set-square and metric straight edge.

By the parallel motion and the simultaneous lateral displacement of the two adjustable compass arms cross-soundings and bearings, as determined by angular measurement, can be set out in a minimum of time, and are easily controlled as the whole operation can be seen at a glance.

When used on charts the protractor is placed with its front edge along a parallel of latitude and the compass-circle is adjusted, with or without allowance for the magnetic variation, by means of the vernier of the alhidada. The remaining steps are obvious.

7. Double Protractor.

8. Sounding Disk for determinations of distances.

9. Deep Sea Sample Drawer.

10. Sea-bottom Drag.

3. Em. E. Meyer, Hamburg, St. Georg, 78 An der Koppel.

Mechanician and Nautical Instrument Maker.

Speciality: Patent Logs, Sextants, Octants.

Silver Medal: Hamburg 1889.

Patent Log Indicator for determining the speed of a vessel at sea, consisting of the counting log and a propeller. The log is screwed to the railing abaft, and the propeller drags a line 70 m

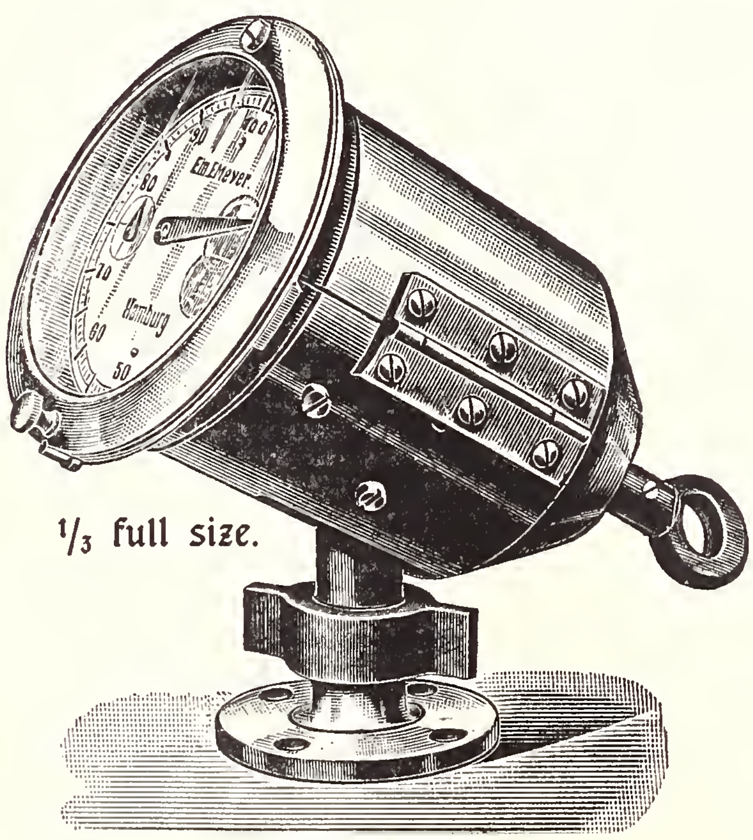


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Fig. 1.

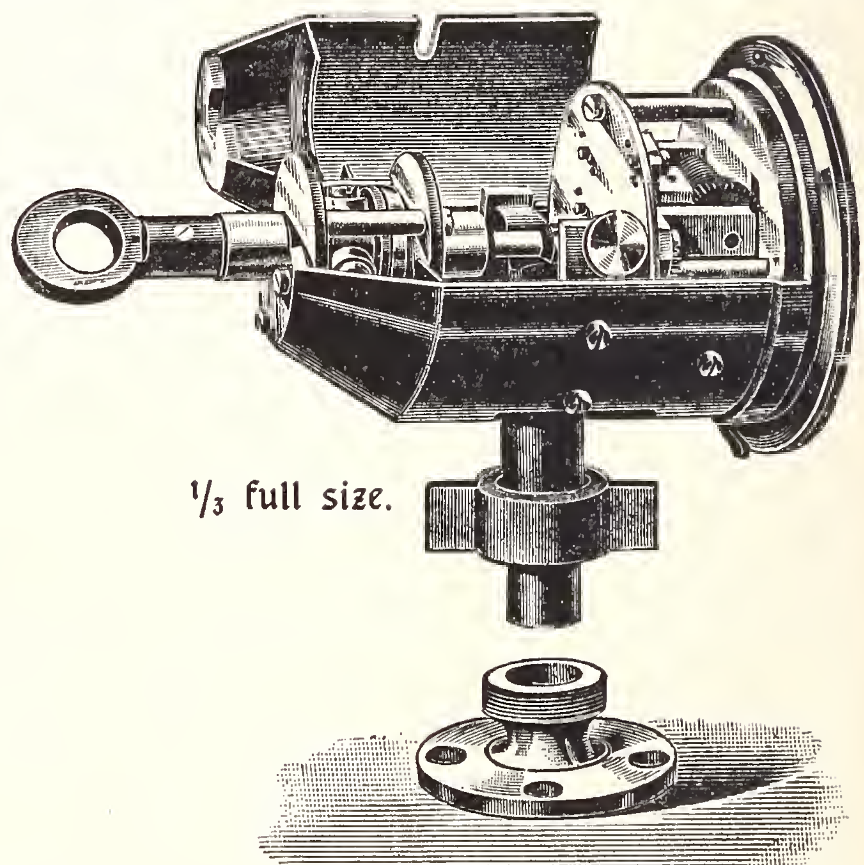

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Fig. 2.

long. The rotation of the propeller is transmitted by the line to the indicator, which shows the distance in knots traversed by the vessel.

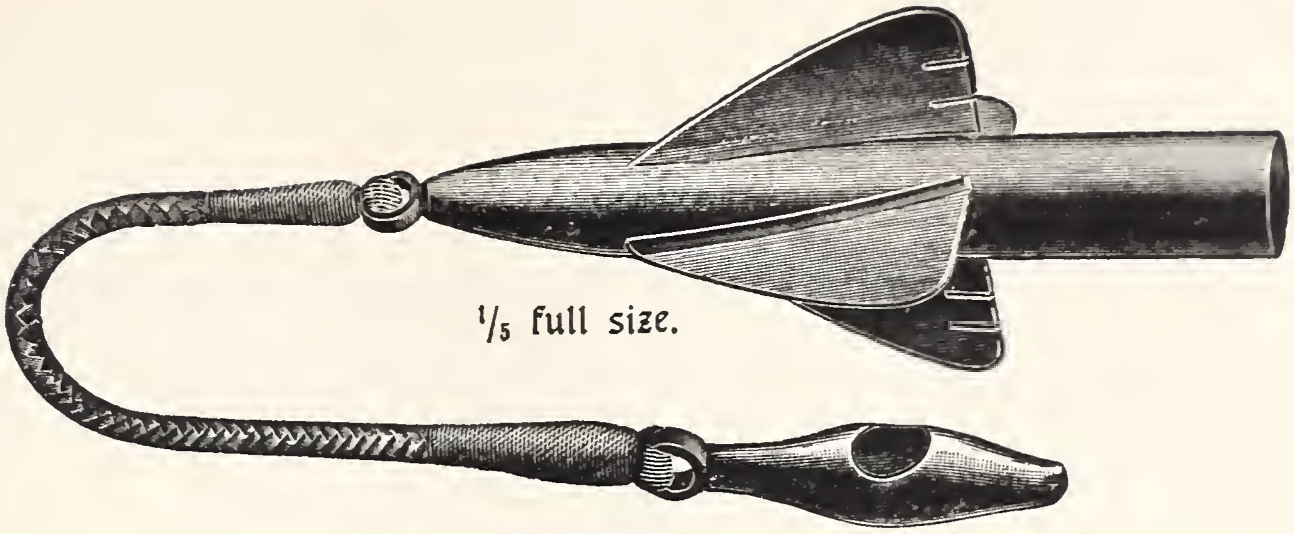


Fig. 3.

A new feature of this Patent Log Indicator, which obtained a silver medal in the Hamburg Trades Exhibition of 1889, consists in the facility provided for completely opening the log while actually working, so as to clean or lubricate it in good time. By this arrangement the spindles are not apt to run dry, and the indicator is protected from irregularity.

4. A. Repsold & Söhne, Hamburg, 96 Borgfelder Mittelweg.

[See also Sections I, II and IIIa.]

Döllen's Prismatic Tube. The accuracy and distinctness attainable in modern dividing engines is such that with the aid of a reading microscope the circle, though only 35 mm in radius, furnishes readings comparable to those attainable with a circle of about 200 mm radius read by a vernier.
The instrument is primarily intended for use on a stand, but it is also available at sea for use in the hand.

This instrument is the property of the Imperial Marine Observatory at Hamburg.

IV. Meteorological, Geo-magnetic, Thermometric and Calorimetric Instruments.

1. Carl Bamberg, Friedenau near Berlin, 39/41 Kaiserallee.

Mechanical and Optical Works.

Established 1871.

Telegraphic address: Bamberg-Friedenau.—Telephone: Friedenau No. 14.

(See also Sections IIIa and IIIc.)

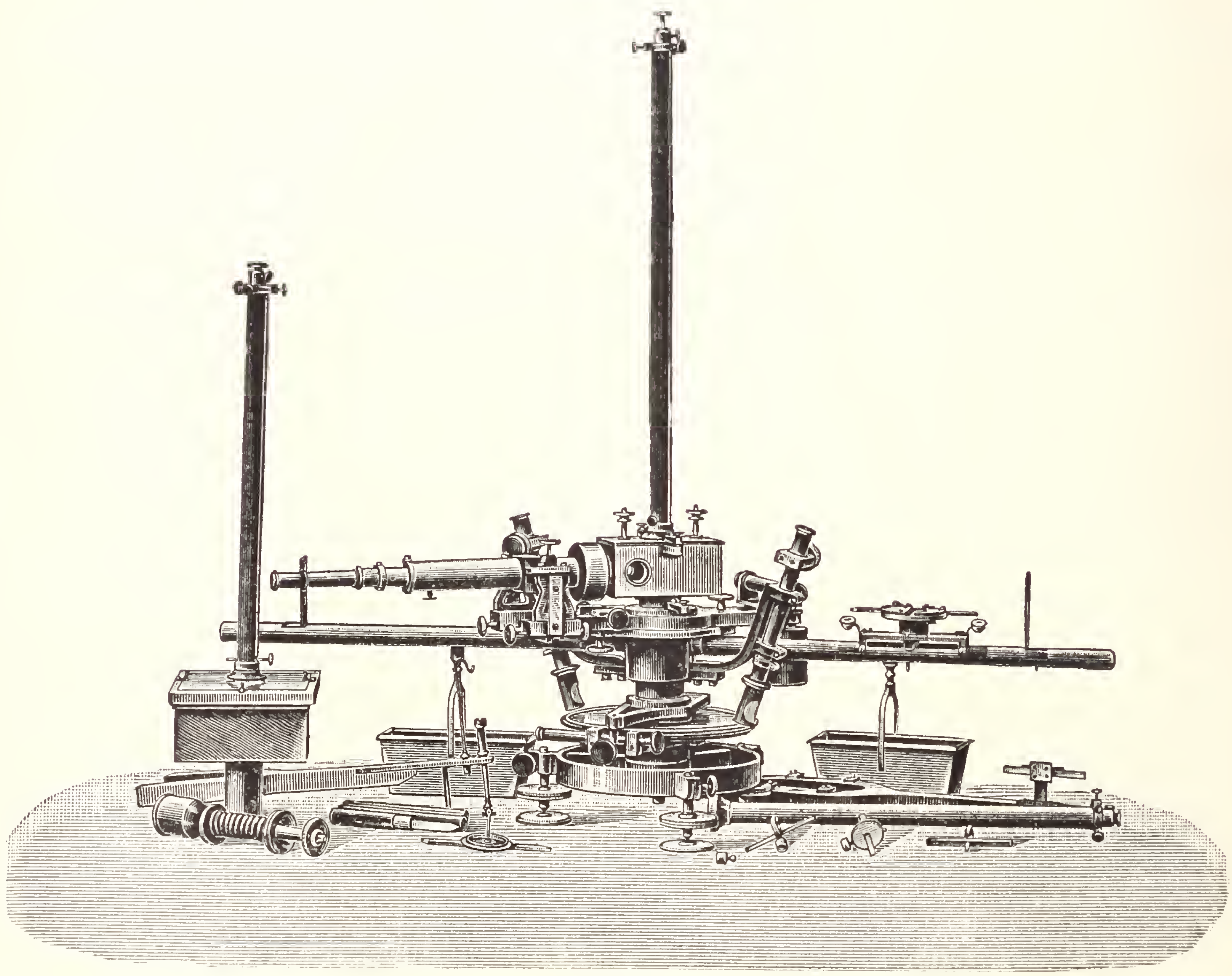


Fig. 1.

1. Magnetic Theodolite for Observatories. Horizontal circle having a diameter of 17 cm, an excentric collimator of 24 mm aperture and 21 cm focus fitted with achromatic microscope eyepiece magnifying 30 times. The deviation rail adapted for sine readings in E.W. and N.S. is detachable, it has a circular section of 15 mm, a length of 850 mm and is divided into centimetres. Fig. 1.

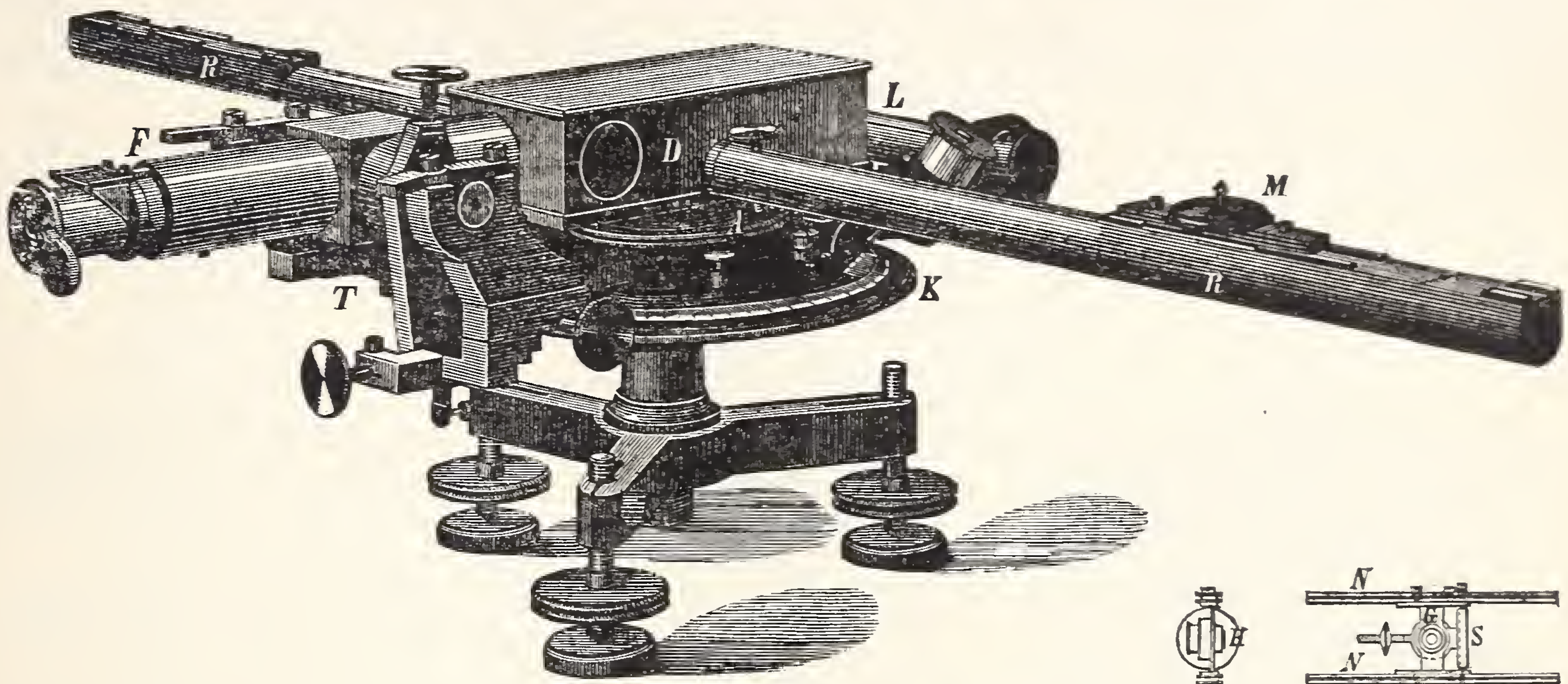


Fig. 2.

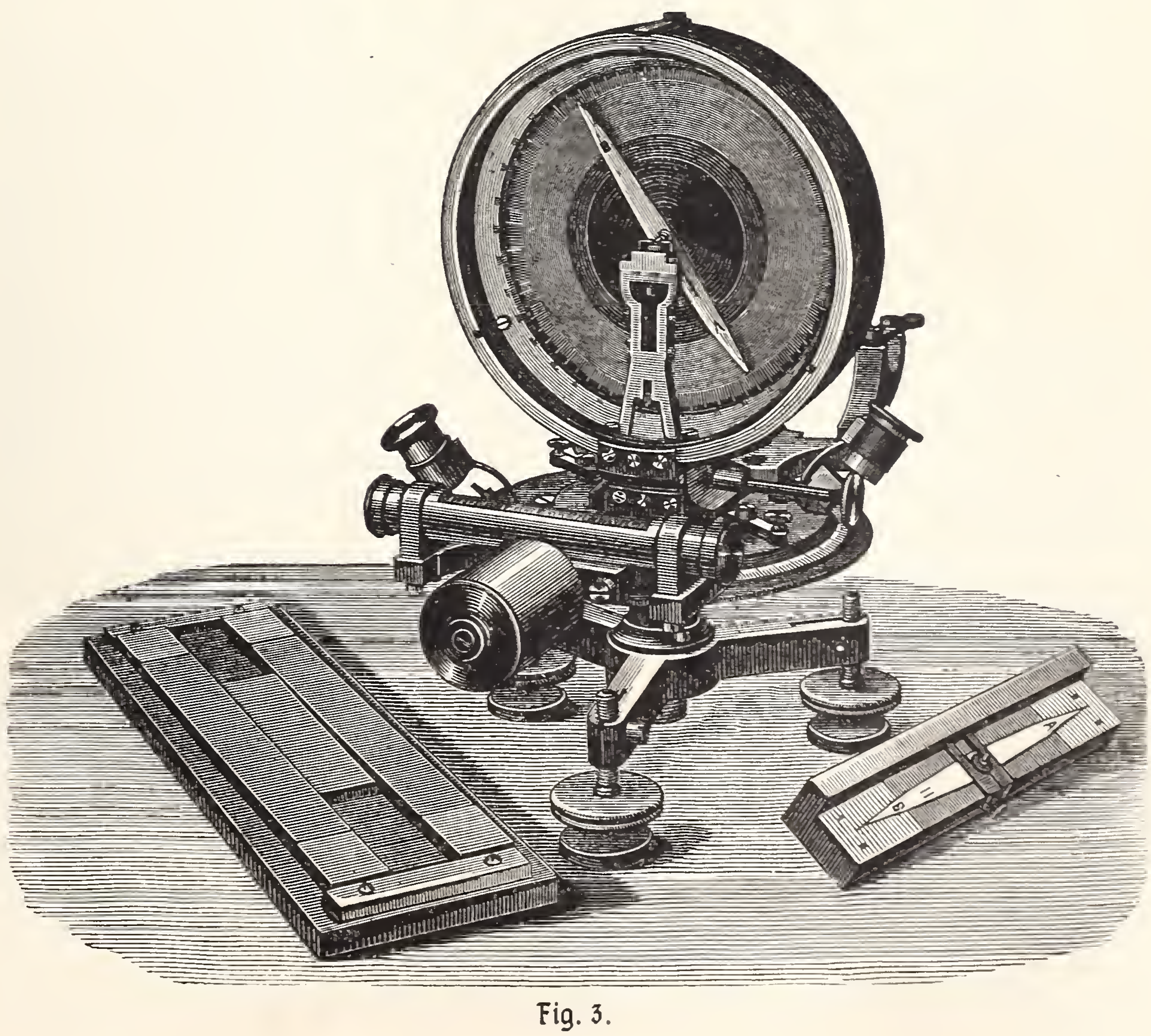


Fig. 3.

2. **Magnetic Travelling Theodolite.** Fig. 2 and 3. Horizontal circle of 13 cm diameter, reading to 30 seconds by opposite verniers. The declination system is reversable, swings on pivots, of which six are provided for interchanging, and is fitted with a convenient form of arresting arrangement. Its movements are read by a mirror and collimator. The instrument is fitted with a small pivoted intensity magnet. The deviation rail is adjusted for sine readings in E.W. at the fixed distances 200 and 254 mm. The outfit includes an oscillating box with scale and filar suspension, inertia ring, a vessel for determining the coefficient of temperature, a reflecting dipping compass with two needles 115 mm long, two striking magnets, magnetizing stage and other accessories.

2. Carl Diederichs (Proprietors: Spindler & Hoyer),

Göttingen-on-the-Leine.

Scientific Instrument Works.

Physical Demonstrating Appliances. Levelling Instruments and Theodolites. Reading Telescopes. Psychological Instruments. Dividing on Metal and Glass. Electrical and Magnetic Measuring Instruments.

Universal Magnetic Travelling Instrument, in which the deviation of the vertical and horizontal needles is observed directly by means of a mirror attached to the needle spindle and a telescope attached to the instrument.

This instrument has been constructed from Prof. Dr. Schaper's designs and is in the possession of the Geo-magnetic Station of Lübeck.

3. R. Fuess, late J. G. Greiner jr. & Geissler,

Steglitz near Berlin, 7/8 Düntherstr.

Mechanical and Optical Works.

(See also Sections III a, V b, V d and V g.)

1. **Sprung-Fuess's Barograph.** A description of the older form of this instrument will be found in the following publications: Bericht über die wissenschaftlichen Instrumente auf der Berliner Gewerbe-Ausstellung 1879, p. 233.—Zeitschr. d. österreichischen Gesellschaft f. Meteorologie 1877, p. 305 and 1881, p. 1.—Zeitschr. f. Instrumentenkunde 1886, p. 189 and 1887, p. 232.—La Lumière electrique 1892, p. 170.

This apparatus consists essentially of a registering balance fitted with a guide roller. It possesses the following distinctive features:—

1. The graphic notations are made in rectangular coordinates in absolutely constant ratios.
2. The friction of the spring against the registering drum is not only approximately but entirely harmless. The curve accordingly may be traced directly upon a stone.
3. The movement is magnified considerably, viz. 1:10. The roller weight can however be shifted so as to yield other ratios.
4. The temperature has no influence upon the readings of the barograph; the tube being simply cylindrical in its entirety. There is only a small residual source of error due to thermal influence, which is compensated by the expansion of the tube below the upper level of the mercury.
5. Errors due to capillarity are corrected by an immersion arrangement.
6. The barograph is for these reasons much more accurate than all earlier designs.

Instead of weighing the column of mercury, as in this instrument, it can be rendered available for the registration of other data, e. g. the weight of rain and snow, dew and hoar-frost, evaporating water, and also the attraction and repulsion of wire spirals through which an electric current is passing.

2. **Hellmann-Fuess's Self-recording Rain-gauge.** Fig. 1. The rain-water is made to collect in a cylindrical vessel containing a float carrying on its upper axis a tracing lever. The scriber transmits the movements of the float to the registering band which is attached to the circumference of a

drum. A clockwork housed within the drum causes the axis to turn once in 24 hours. As soon as 10 mm of rain have fallen the cylindrical vessel is automatically emptied by a glass syphon and the scriber immediately returns to the zero line. The tracings are very distinct, the dimensions being selected so as to make each interval of one hour 15.9 mm and each millimetre of rainfall 8.2 mm on the paper. See Meteorol. Zeitschr. 1897, p. 41.

3. Sprung-Fuess's Electrical Registering Anemometer. For description see Zeitschr. f. Instrumentenk. 1889, p. 90, and Meteorol. Zeitschr. 1889, p. 344.

This instrument consists of external fittings and the registering apparatus.

a. The external fittings comprise Robinson's cross-bowls and a vane, the axes of which are all placed vertically one above the other so as to ensure uniform exposure at all directions of the wind.

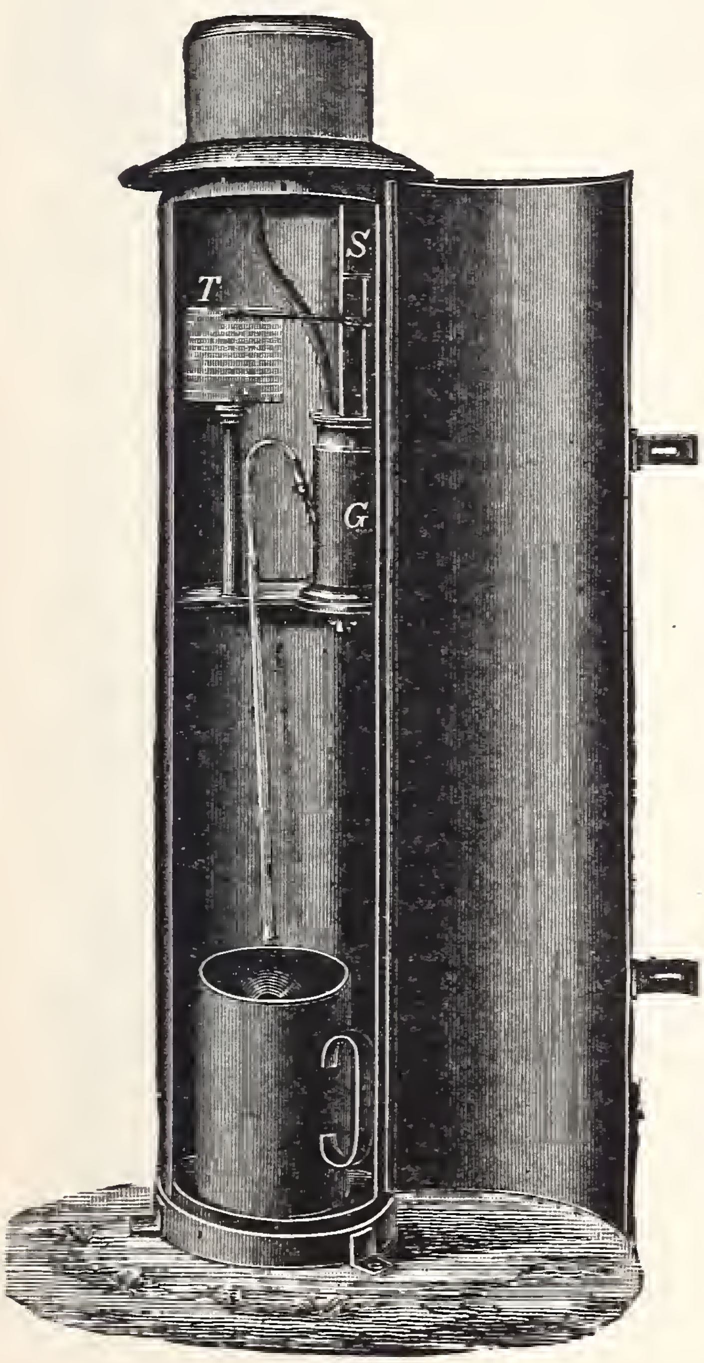


Fig. 1.

Fig. 5.

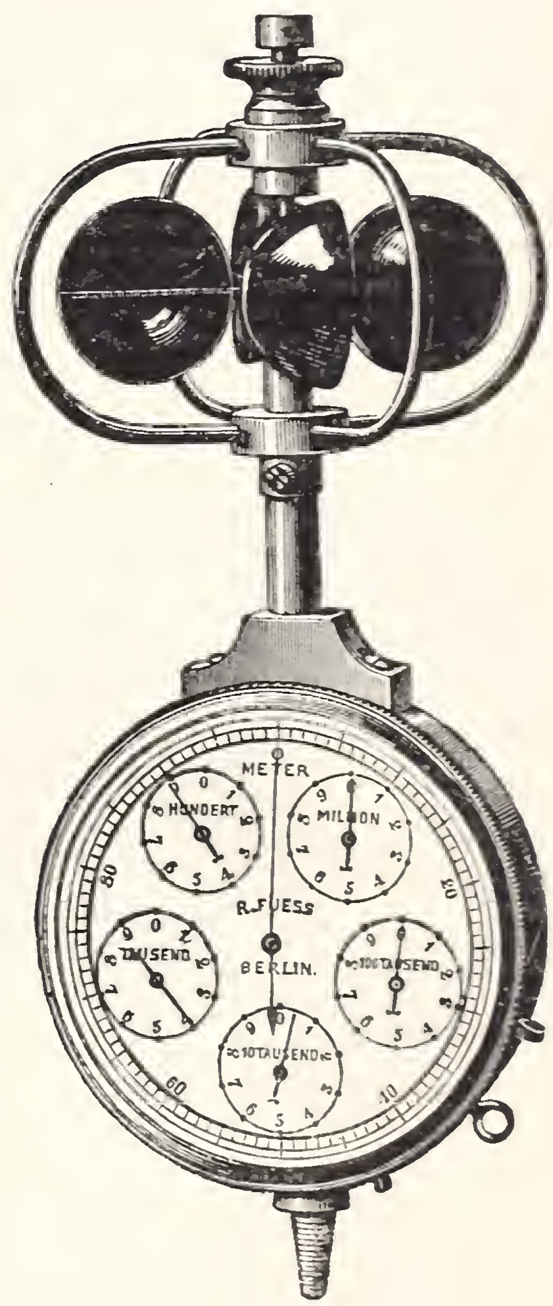


Fig. 2.

Both the cross-bowls and vane rest upon a steel point so as to reduce friction to a minimum. The cross-bowls are very small and light in order to diminish the momentum of inertia as far as possible and consequently to ensure prompt response to rapid fluctuations of velocity.

b. The registering apparatus is of novel design inasmuch as the paper band is not propelled by the clock but by the wind itself through the instrumentality of an electro-magnetic escapement whilst the clock traces horizontal hour lines. Consequently, the interval on the paper between two hour lines is proportional to the summary rotation of the cross-bowls and therefore also to the wind-way corresponding to that hour. This feature renders the apparatus eminently adapted for the preparation of the customary wind charts of meteorological stations.

In addition, the changes in the velocity of the wind are registered within the interval of one hour since the clock causes the scriber to gradually move within the space of an hour from the left to the

right side of the paper band, after which it suddenly returns, tracing while doing so the hour line referred to. The direction of the wind is registered by four small scribers, the tracing indicating 8 points of the compass directly, and even 16 by estimate.

4. Sprung-Fuess's Electrically Registering Rain-gauge, as described in the Zeitschr. f. Instrumentenk. 1889, p. 90, and Meteorol. Zeitschr. 1889, p. 344.

The apparatus consists of the external fittings and the registering instrument.

a. The external fittings consist of a double cased bin within which a so-called Horner's rocker is actuated by the rain-water collecting above. As soon as $^1/_{20}$ mm of rain has collected the rocker overbalances and at the same time sends an electric current through the registering apparatus. During winter the bin is heated by hot water, which automatically maintains in the collecting funnel a temperature of 2 or 3° C., such as is best adapted for melting the snow. For this purpose the apparatus is fitted with a thermo-regulator, the thermometric vessel of which is placed into the double casing of the collecting funnel. The mercury column regulating the gas inlet is within the bin whereas the heating and

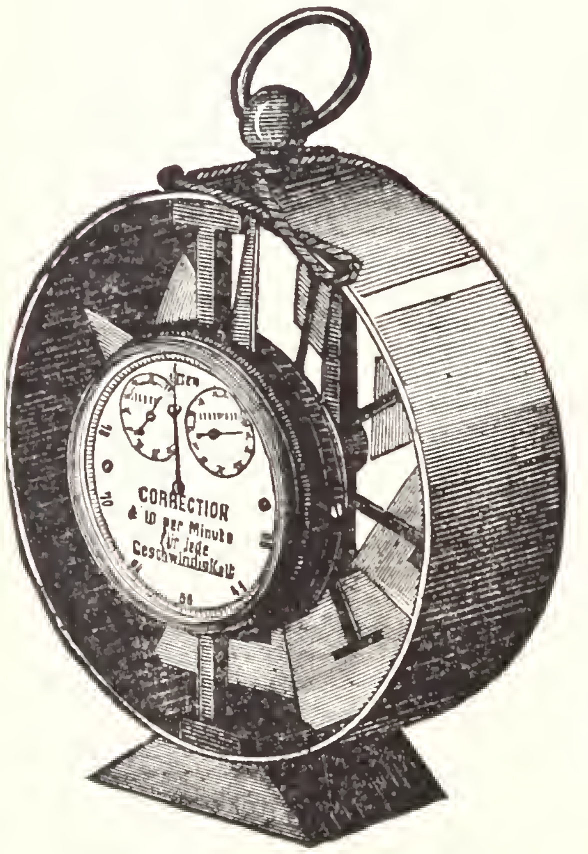


Fig. 3.

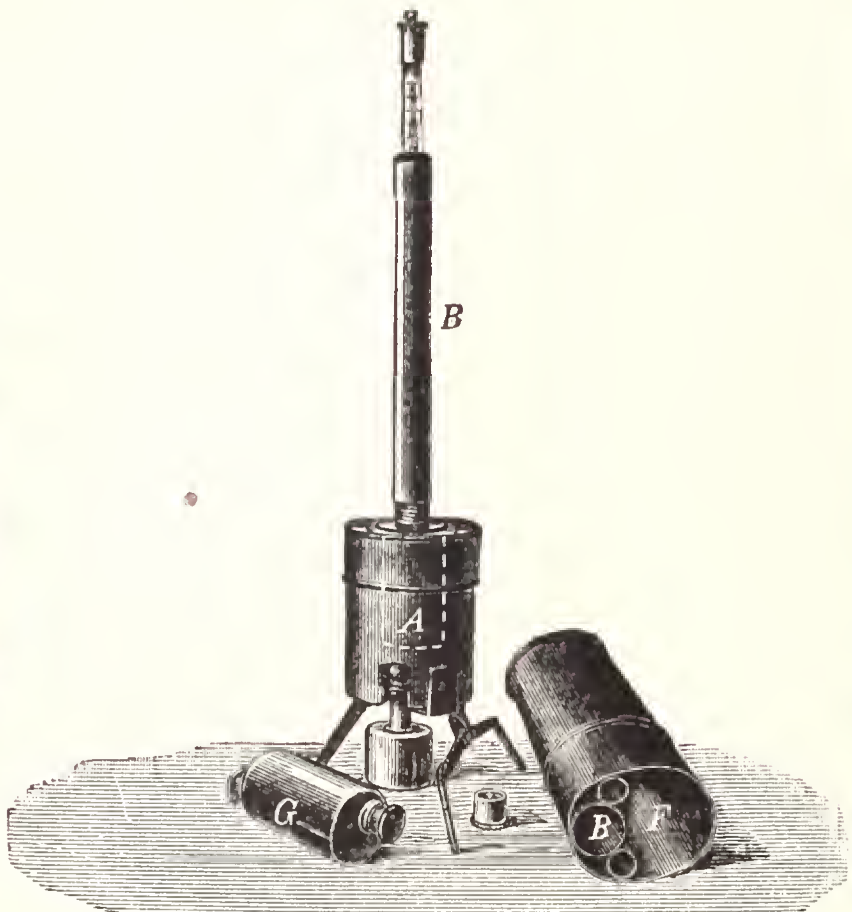


Fig. 6.

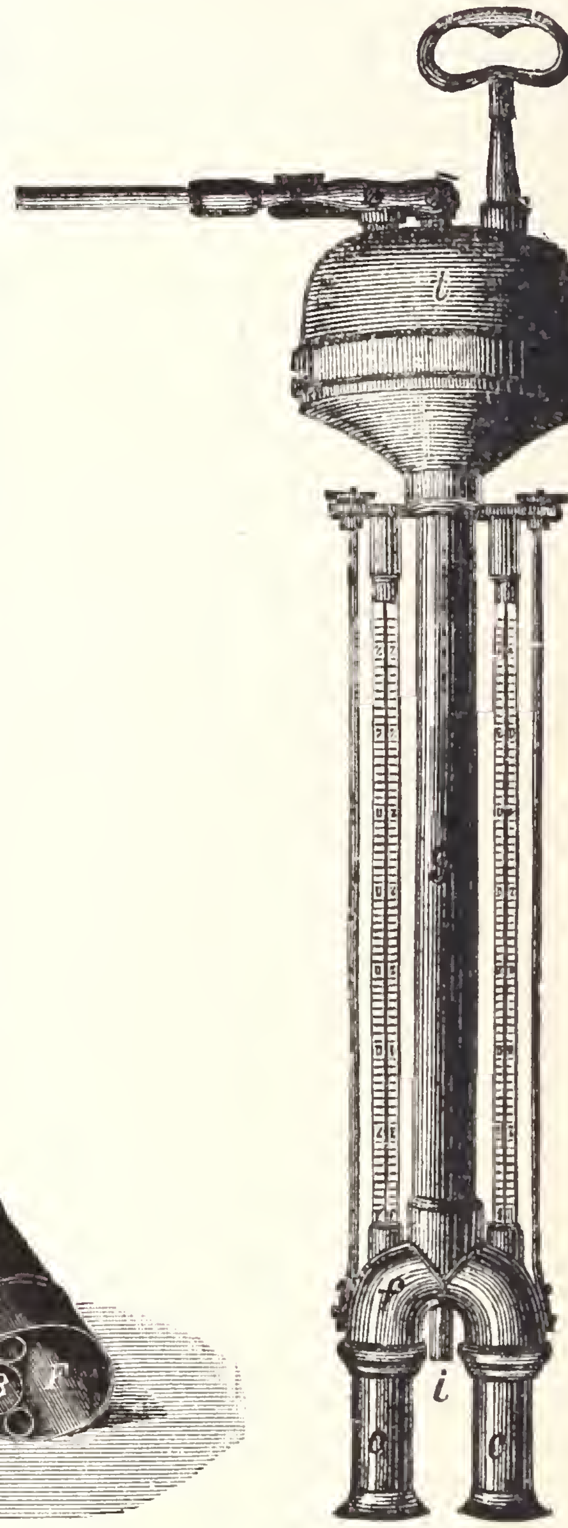


Fig. 4.

by-pass flames are housed in a separate casing so as to prevent corrosion through the gases of combustion.

b. The registering apparatus is almost identical with that of the anemometer No. 3, excepting that, naturally, the four direction-springs are absent. The current is not only closed by the movement of the wind or weight of the rain-water, as the case may be, but it is, in addition, gradually turned by the clock. This feature is particularly important in the case of the rain-gauge. Immediately after the quick return motion of the scriber to the left the paper band is made to advance a small distance, the action being the same as that which takes place when the rocker is tilted. This distance is subsequently deducted, the necessity of the gap arising from the fact that in dry weather it would otherwise not be possible to separate the hour-lines. Cross ruling of the band signifies therefore rainless weather and is equivalent to zero.

The uniform movement of the scriber is twice as large in the case of the rain-gauge as compared with the anemometer, amounting, accordingly, to 1 mm per minute. The object of this large movement is to render the apparatus sufficiently exact for the purpose of making a rigorous comparison between the rainfalls at distant stations.

5. Campbell-Stokes's Sunshine Recorder, adjustable for different degrees of latitude.

6. **Pocket Anemometer** with cross-bowls. Fig. 2.

7. **Anemometer No. II**, counting up to 10,000 m, with ventilating propeller. Fig. 3.

8. **Anemometer No. IV**, counting up to 1,000 m.

9. **Dr. Assmann's Aspirating Psychrometer** as described in the Zeitschr. f. Instrumentenk. 1892, p. 1. Fig. 4.

10. **Pocket Aspirating Psychrometer**, Fig. 5, as described in Jelinek's Anleitung zur Ausführung meteorologischer Beobachtungen, &c., IV. Edition, II. Part, p. 4.

11. **Wild-Fuess's Precision Barometer.**

12. **Wild-Fuess's Standard Barometer** as described in the Instruktion des Königlich Preussischen Meteorologischen Instituts für die Beobachter an den meteorologischen Stationen, Berlin 1888. Asher & Co. Wild, ibid.

13. **Station Barometer** as described in the "Instructions" referred to.

14. **Hellmann's Light Travelling Barometer**, mounted upon a wooden lath fitted with silvered brass-scale and bayonet joint. Owing to its small weight, which does not exceed 1.8 kg including a leather case, it is particularly adapted for inspecting work. See Meteorolog. Zeitschrift 1897, p. 350.

15. **Schubert's Psychrometer**, as described in the Zeitschr. f. Instrumentenk. 1896, p. 329.

16. **Stationary Psychrometer** with aspirator, with maximum and minimum thermometer.

17. **Maximum and Minimum Thermometers** for No. 16.

18. **Insolation Thermometer.**

19. - - , adjusted for maximum readings.

20. **Water Thermometer** with scooping vessel.

21. **Marine Thermometer** with scooping vessel.

22. **Minimum Thermometer** with filling of toluol.

23. **Freezing Point Thermometer**, divided into $^1/_{100}$ degrees.

24. **Prof. Dr. von Danckelman's Hypsometer.** Fig. 6.

25. **Hypsometer** in wooden box, as described by Fr. Grützmacher, Zeitschr. f. Instrumentenk. 1897, p. 193.

26. **Large Standard Thermometer** with arbitrary graduation of $^1/_{10}°$ from 0 to 102° C.

27. - - - divided into $^1/_{10}°$ from 0 to 102° C.

28. - - - - - $^1/_{10}°$ from 30 to 102° C. with an enlargement within the interval from 50 to 97° C.

29. - - - - - $^1/_{10}°$ from −30 to +50° C.

30. **Beckmann's Large Standard Thermometer**, divided into $^1/_{100}°$ C.

31. **An Assortment of Ten Thermometers.**

Instruments Nos. 1, 3, 4 and 14 are the property of the Royal Meteorological Institute of Berlin-Potsdam. It was intended to include in the exhibits **Sprung-Fuess's Automatic Photogrammetric Cloud Recorder**, but the instrument could not be spared. The nature of the apparatus will be seen from a photograph accompanied by five photograms. The latter should be taken in pairs joining from left to right, the photographs being taken concurrently at the extremities of a base of 1469 m, the camera being turned vertically upwards. A small cloud which in one camera appears exactly in the middle of the plate is shown parallactically displaced in the other, the amount of the displacement depending upon the nearness of the cloud. The apparatus registers therefore immediately the altitude of the clouds, and by taking two double photograms successively their speeds and directions can be measured. The photograms Nos. 448 and 449 are connected in this manner; the other photograms are independent and serve exclusively for determining the altitude, the velocity and direction being determinable by the additional aid of a nephoscope or cloud-mirror.

The apparatus works automatically a rain cap, and after the exposure also a plate-changer and a device for adjusting the position of the fresh plate, after which it is ready for renewed action.

See Rapport du Comité météor. internat., réunion d'Upsal, 1894. Meteorol. Zeitschr. 1895, p. 217. Zeitschr. f. Instrumentenk. 1899, pp. 111 and 129.

4. F. O. R. Goetze, Leipzig, 4 Härtelstr.

Prof. E. Beckmann's Thermometer with variable mercury charge for determining small differences of temperature at all temperatures which can be measured in evacuated mercury thermometers (Zeitschr. f. physikal. Chemie II, p. 644; XV, p. 672; XXI, p. 252).

Fig. 1.

The scales embrace but a small number of degrees figured in an upward succession and are divided into $^1/_{100}$ and $^1/_{500}$ degrees respectively, and with the aid of a magnifier can be made to read $^1/_{1000}$ and $^1/_{5000}$° C. respectively.

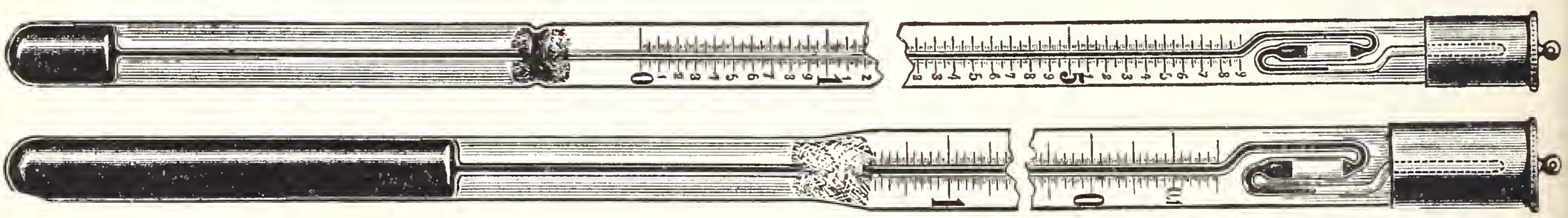
A characteristic feature of these thermometers is the looped form of the mercury reservoir (Fig. 1), by means of which any desired quantity of mercury can readily be separated from the bulk of the mercury in such a manner as to obviate the return flow of the mercury thus isolated. With equal ease the whole or any portion of the isolated mercury can be made to flow back to the main column.

In addition, these thermometers possess the following distinctive features:—Their scales are made of opal glass hermetically enclosed in the outer glass tube, and hence extremely fine divisions can be clearly seen without effort. A neck or stem of appropriate length is made to intervene between the bulb and the capillary tube so as to utilize the full length of the scale.

The exhibits comprise:—

a. **Thermometers** for freezing and boiling tests, with short bulbs so as to avoid high fluid strata when determining boiling points. Intervals of $^1/_{100}$°. Fig. 2.

b. **Thermometers** for freezing tests, with long bulbs. Intervals of $^1/_{500}$°. Fig. 3.



Figs. 2 and 3. $^2/_5$ full size.

In addition, the following thermometers are made:—

Range of scale:	1 degree.	Intervals: $^1/_{500}$ degree.
- - -	5 to 6 degrees.	- $^1/_{100}$ -
- - -	10 - 12 -	- $^1/_{50}$ -
- - -	25 - 30 -	- $^1/_{20}$ -
- - -	50 - 60 -	- $^1/_{10}$ -

Thermometers are also graduated in any other manner, to suit special requirements.

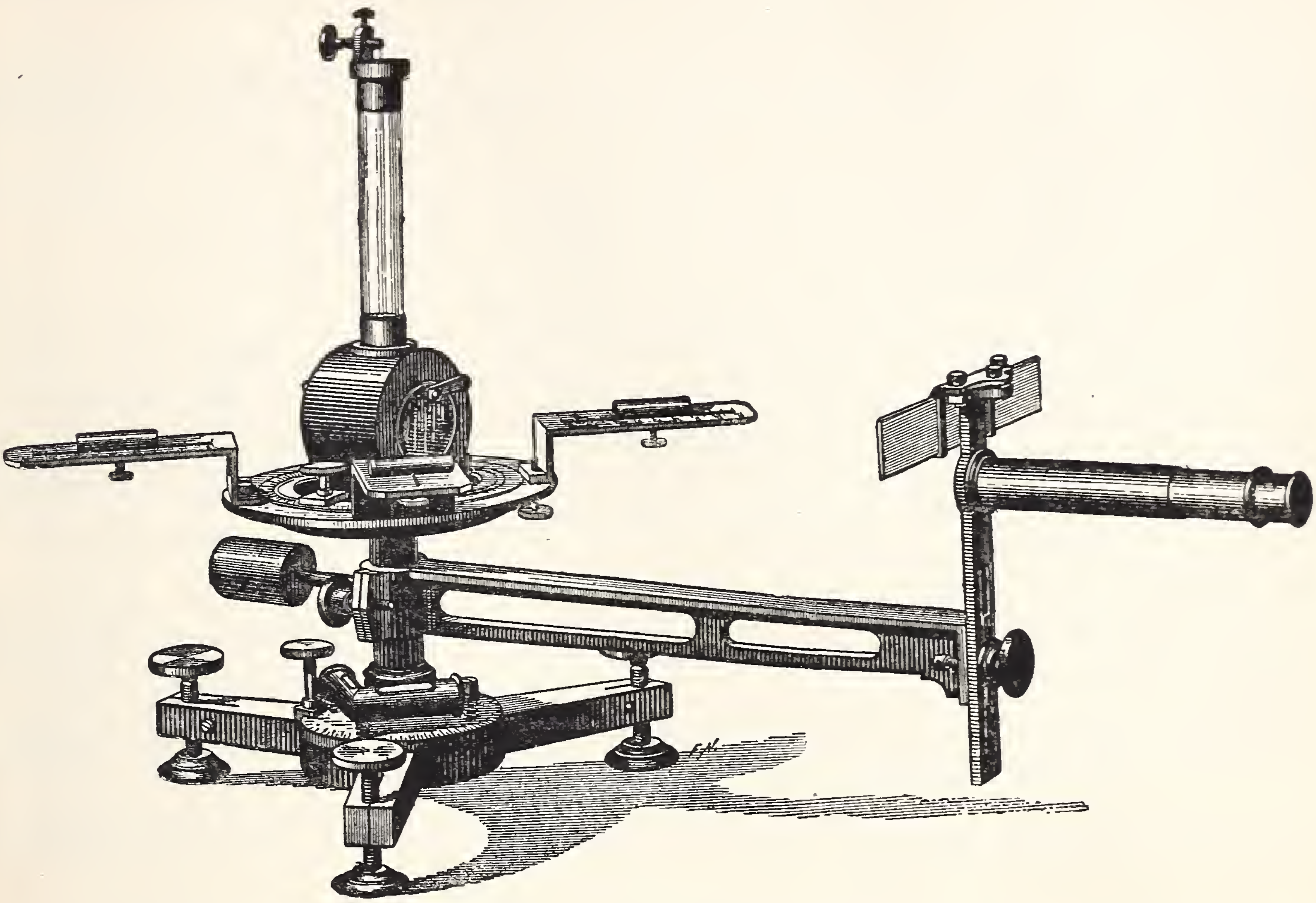
5. Hartmann & Braun, Frankfort-on-the-Main.

Makers of Electrical Measuring Instruments.

(See also Section VI.)

1. **Fr. Kohlrausch's Earth-magnetic Bifilar Variometer** (Firm's catalogue No. 410). In contradistinction to Gauss's instrument this variometer is fitted with a small tubular dead-beat magnet influencing its vicinity only in a slight degree. The constant is determined simply by the torsion-head, and the suspension controlled by means of adjustable mirrors.

2. **Fr. Kohlrausch's Earth-magnetic Variometer** with directly attached reading telescope (Firm's catalogue No. 411).



Four bar-magnets are employed to deflect the suspended steel magnet mirror and produce in their vicinity a very uniform field; they can be moved so as to vary the required degree of sensitiveness. The magnet needle is deflected 90° out of the meridian, oscillations of the declination have accordingly no influence upon the readings.

The horizontal intensities of terrestrial magnetism at different places can accordingly be compared with great nicety (1:10,000).

3. **Fr. Kohlrausch's Simple Local Variometer** for determining the local changes of the horizontal intensity (Firm's catalogue No. 411 a). The method of observation and the general principle of the instrument are the same as with the intensity variometer, but the instrument is simpler and more portable. Its degree of accuracy suffices for most purposes (1:1,000).

4. **Fr. Kohlrausch's Unifilar Magnetometer.** The magnet is attached to the back of the mirror which at the same time serves as an air damper (Firm's catalogue No. 415), or as an annular magnet in a copper damper, capable of rotation with respect to the mirror, and mounted with a minimum use of metal (No. 415 a).

5. **Gauss and Weber's Magnetometer** for determining the horizontal intensity and declination (Firm's catalogue No. 421).

6. **L. Weber's Differential Earth-magnetic Inductor** (Firm's catalogue No. 426), containing two similar coils the positions of which are interchangeable, and mounted so that they can be turned 180° round their axes which are placed at right angles to each other.

A single minute suffices to determine the inclination angle with the aid of a differential galvanometer in which the currents passing through each coil are made equally strong by appropriate shunts. The ratio of the shunt resistances gives the tangent of the angle of inclination.

This instrument is the property of the Physical Institute of the University of Kiel.

6. W. C. Heraeus, Hanau.

Platinum Smelter and Mechanician.

This firm has, at the instigation of the Imperial Physical and Technical Institute of Charlottenburg, occupied itself continuously for the last few years with the preparation of pure metals of the platinum group. The latter can now be supplied in considerable quantities and in an almost absolutely pure state.

These pure metals have been applied to various scientific purposes by the Imperial Physical and Technical Institute and are partly used for technical purposes. This applies in particular to pure platinum and rhodium as used in the manufacture of Le Chatelier's thermo-electric couples.

The possession of pure platinum has led to the production of platinum alloys which formerly, being prepared from impure metals, could not be put to practical uses.

This applies in particular to the platinum-iridium alloys, which, though containing a high percentage of iridium, possess all the properties of platinum and, in addition, a degree of hardness which is similar to that of steel. This has rendered platinum available for use in several departments from which it was formerly excluded. Mr. Herm. Frommholz, of Berlin, makes, e. g., platinum-iridium canulae of platinum alloyed with 30 per cent of iridium, the demand for which is increasing annually. Platinic alloys constitute invaluable elements in the manufacture of many medical and scientific appliances, owing, principally, to the invariable properties resulting from the purity of the metal. Pure iridium, which is even harder than platinum-iridium, is employed, in the construction of many scientific instruments, in the form of fine disks and rods.

The exhibits include:—

1. **Le Chatelier's Thermo-electric Couple,** in the exhibit of the Imperial Physical and Technical Institute of Charlottenburg, and of Messrs. Keiser & Schmidt and Siemens & Halske, of Berlin.

2. **Rods** of pure platinum, palladium, rhodium and iridium, in the exhibit of the Imperial Physical and Technical Institute.

7. Junkers & Co., Dessau.

Works: Junkers & Co., Dessau, Germany.

Representative: Arthur Schleicher, Paris, 173 Rue St.-Martin.

State Medal: Munich 1898. Gold Medal: Rheidt 1899. Silver State Medal: Berlin 1899.

1. **Prof. Junker's Calorimeter.** Patented in nearly all countries. Highest awards: Chicago 1893, Erfurt 1894, Leipzig 1897, Munich 1898.

This calorimeter serves to quickly and accurately determine the caloric value of gaseous and fluid combustibles. Fig. 1.

The combustible is consumed by a suitable burner with an open flame within a compact vessel provided with a large heating surface and is made to give off the whole of the heat evolved to a uniform current of water flowing through the vessel so as to establish a state of inertia, when at any given instant the amount of heat carried away by the current of water is equal to that generated by the combustion.

The caloric value is determined by multiplying the amount of water corresponding to the given quantity of the combustible by the increase of temperature and dividing by the quantity of gas burned.

The calorimeter has been tested by many authorities, e. g. the Imperial Physical and Technical Institute of Charlottenburg and Prof. Slaby, who have certified a degree of accuracy which agreed within 0.4 per cent with the best known strictly scientific methods. In spite of its great exactness the instrument is well adapted for practical purposes; it does not necessitate any determination of the thermic water-value, &c., and can be worked in a few minutes by any untrained person.

The calorimeter is being used in coal- and water-gas works, motor works, blast-furnaces, technical colleges, laboratories, &c. for determining the caloric value of coal-gas, water-gas, acetylene gas, generator-gas, Dawson-gas, cupola-gas, petroleum, naphtha, ligroïne, benzine, benzole, spirit, &c.

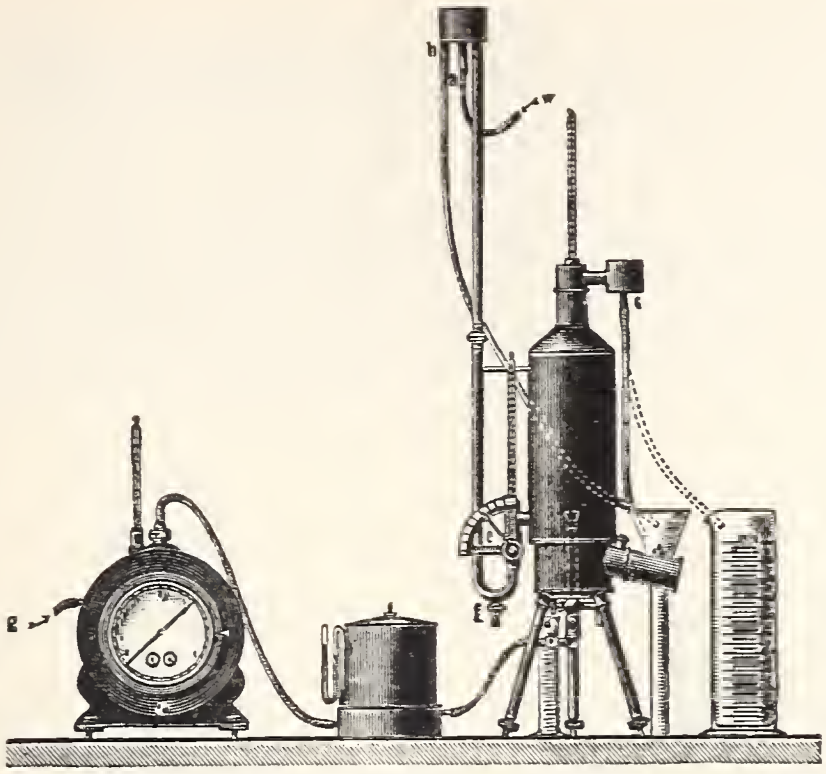


Fig. 1.

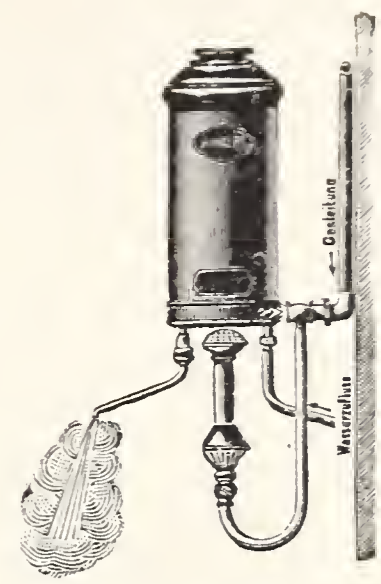


Fig. 2.

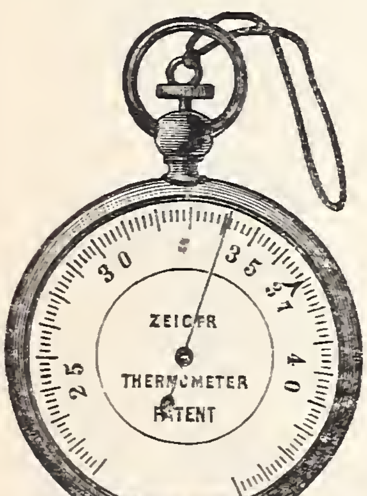
2. Prof. Junker's Rapid Water Heater and Gas Bath-heater (on the same principle as the calorimeter and similarly constructed). Fig. 2. Water-current heaters for the rapid and economical generation of a continuous current of warm, hot or boiling water. The gases are fully utilized to within 92 per cent, as certified by official tests. They are made in various sizes to suit existing requirements, i. e., for 60, 120, 200, 300, 450 calories per minute and more. These heaters are being used by physicians and surgeons, dentists, coiffeurs, in restaurants, cafés, kitchens, bed-rooms, lavatories, and bathrooms, for the maintenance of entire domestic water-heating pipes, for rinsing wine-, beer- and milk-bottles, photographic and lithographic plates and other commercial and domestic purposes.

8. Ernst Loewe, Zittau (Saxony).

Philosophical Instrument Maker.

Highest Award: International Medical Congress, London.

Silver Medals: London, Antwerp, Liverpool, Falmouth, Melbourne, Görlitz.



Full size.

Metallic Index Maximum Thermometer, described as the best existing fever-thermometer. This thermometer can be guaranteed to remain reliable. It is unchangeable, permanent and unbreakable, and can be repaired at any time. It is supplied with certificates by the Imperial Physical and Technical Institute of Charlottenburg.

Many of the highest authorities testify to its excellent qualities. Over 20,000 of these thermometers have been supplied.

To be obtained through any important instrument dealer, or from the manufacturers.

9. G. Lufft, Stuttgart.

Maker of Metallic Barometers.

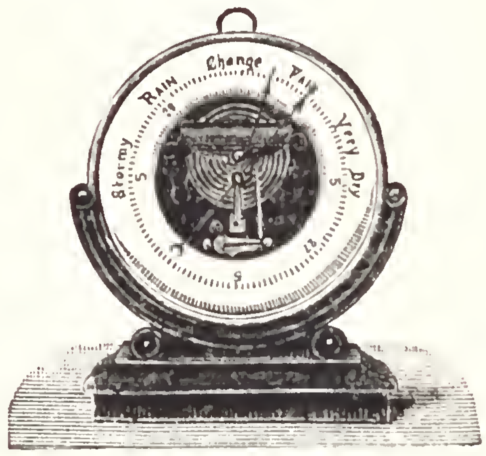
Largest Establishment for the Manufacture of Metallic Barometers.

Highest Awards.

This firm was established in 1880 and undertakes exclusively the manufacture of metallic barometers, of which many thousands are exported annually to all parts of the world. Attention is primarily

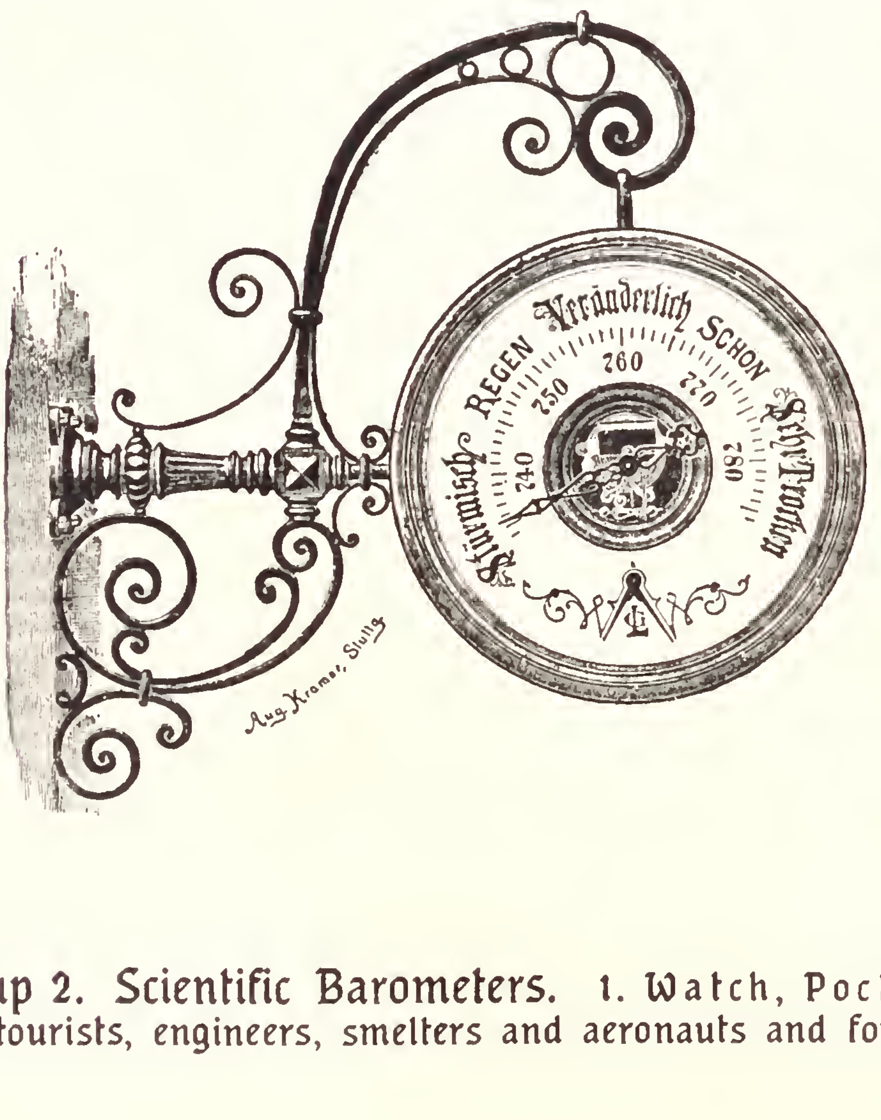
bestowed upon accuracy and suitable designing. The exhibits are intended to illustrate the high standard of accuracy reached by this firm, in consequence of which its productions, wherever exhibited, have invariably been awarded the highest distinctions. The various objects of manufacture are represented by a large assortment of barometers divided into two groups.

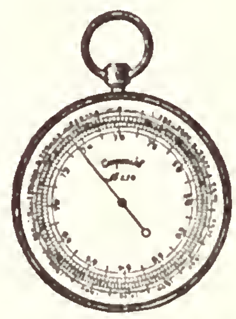
Group 1. Ornamental Barometers. These are made in a great variety of styles and sizes, both for hanging and standing, in metal cases and wooden frames, with and without thermometers. The indications are extremely accurate and so large as to disclose even very small oscillations of pressure. The weather chart is inscribed in any of 23 languages.

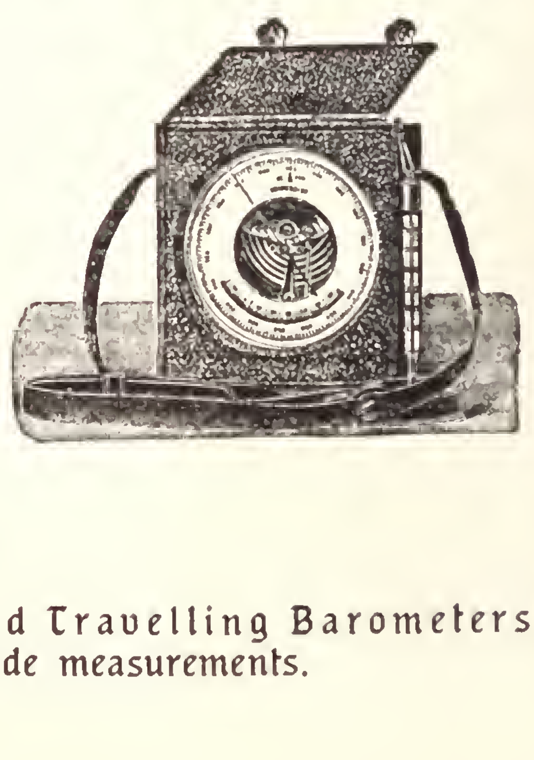


The largest of these barometers are designed for advertising purposes, e. g. in front of opticians' shops and for public use. Their dials vary from 35 cm to 2 m and their movements are correspondingly large, distinct and exact.

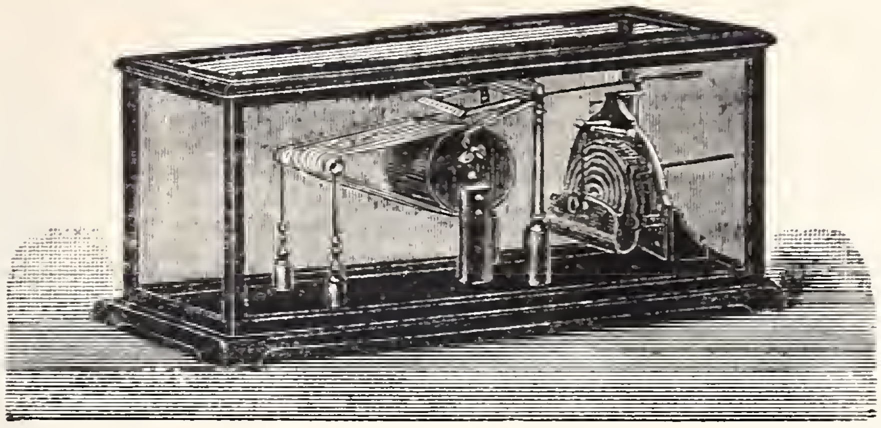
The large Advertising Barometer is suspended from an elegant wrought iron bracket. The dial has a diameter of 60 cm, and shows on one side a barometer, on the other a thermometer.

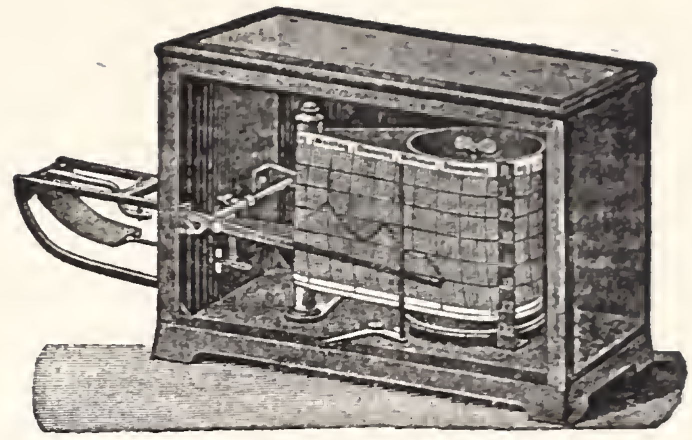


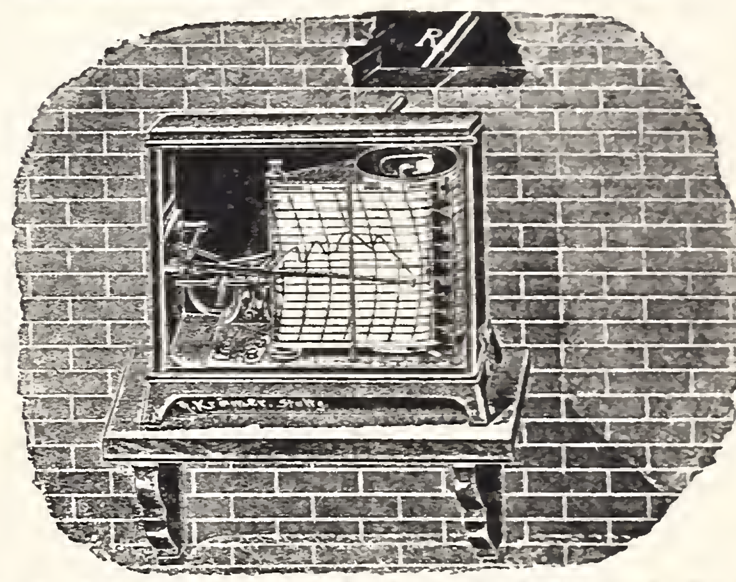




Group 2. Scientific Barometers. 1. Watch, Pocket and Travelling Barometers for the use of tourists, engineers, smelters and aeronauts and for altitude measurements.

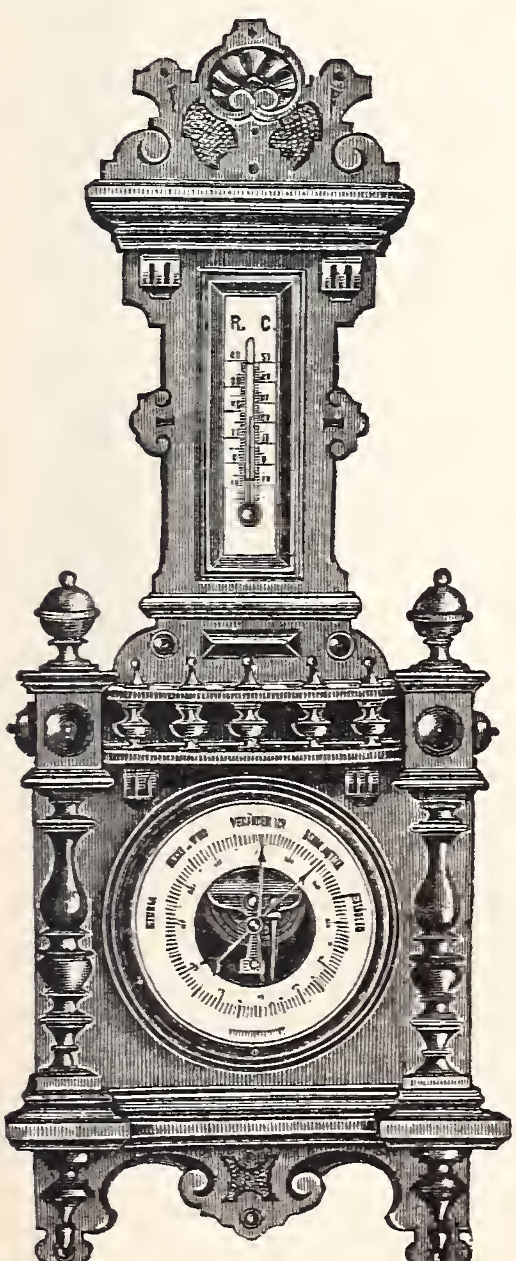






2. Registering Instruments. Self-recording Barometers. Registering Thermometers. Registering Thermometers for breweries and malt-rooms, to read from without.

Each instrument bears a trade-mark. The wholesale trade only is supplied.



10. Möller & Sander,

Altona-on-the-Elbe,

64 Friedenstr.

Proprietor: J. H. Möller.

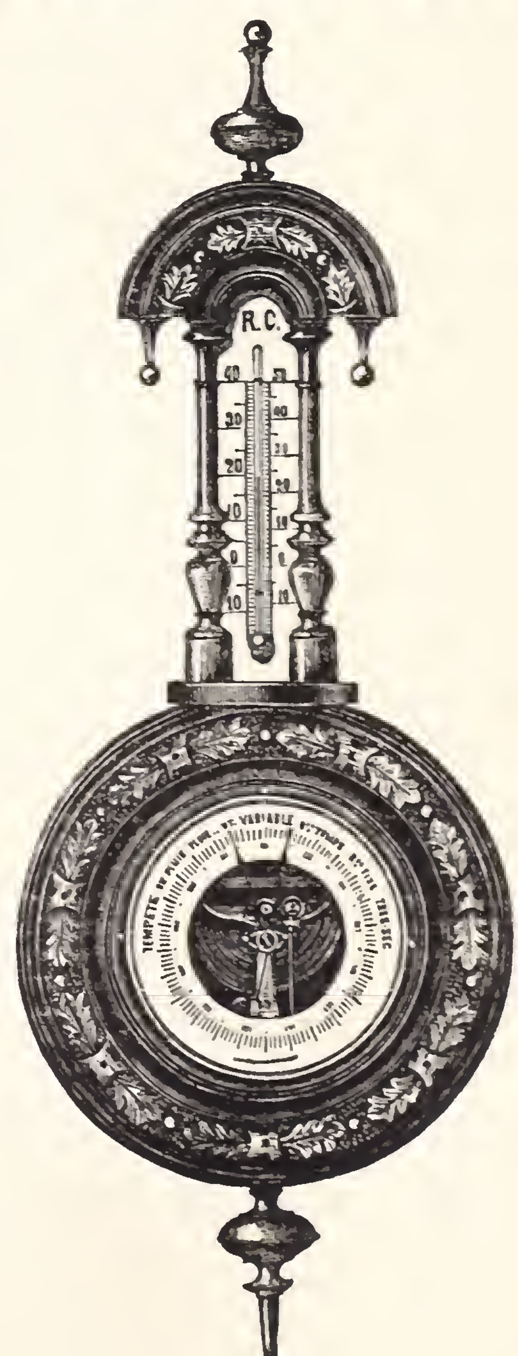
Metallic Barometer Works.

Awards:
Hamburg 1889, Altona 1889, Kiel 1896.

Holosteric Barometers
in wood and metal frames.

Scales
in all modern languages.

Information may be obtained from the Deutsche Seewarte, Hamburg.



11. W. Niehls, Berlin N., 171 Schönhauser Allee.

Maker of Technical Glass Appliances and Measuring Instruments.
Established 1882.

Awards:

1893. Chicago, Three highest awards.
1895. Lübeck, Gold Medal.
1897. Berlin, Silver State Medal.
1898. Düsseldorf, highest award.
1899. Budapest, Silver Medal.

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1. **The High Grade Rod-thermometers** exhibited are divided up to +550° or 580° C. The graduations and lettering are, by an original process, first etched and subsequently burned in. These thermometers are filled under pressure with a dry gas (CO_2N), and were first made by Dr. Schott, of Jena.

The first high grade thermometers did not reach beyond 500° C., the pressure on the mercury being about 10 to 12 atmospheres. The thermometers subsequently made by the firm for the Imperial Physical and Technical Institute reached up to 550° C., the pressure above the mercury being 20 atmospheres. Of these thermometers upwards of 2000 have been made and supplied to public offices and private users. Thermometers reading with sufficient accuracy as high as +580° C. have not been made until recently, a rod-thermometer of this kind having first been shown by the firm in 1895 at the Meeting of the German Glass Instrument Makers held at Jena.

Each of the thermometers made under pressure is fitted at the upper end of the capillary with a protector, isolating by a dish and small hook the lower from the upper section, so as to securely protect the capillary from clogging by accidentally disruptured particles of the sealing medium. This protector is registered.

2. **Niehls's Glass Hardness Scale** is intended for use in schools and colleges, in laboratories and glass warehouses. Each case is provided with full directions. In the order of succession of the glasses No. 1 is the softest glass used commercially, this is followed by glasses of gradually increasing degrees of hardness, and the last number represents the hardest of the glasses in use.

3. **Breguet's Metallic Thermometer** for class demonstrations fitted with a suitable scale, as supplied to many schools. Registered.

4. **Prof. Eschenhagen's Tele-thermometer** for determining the temperature of distant places with the aid of telephones or galvanometers (see Zeitschr. f. Instrumentenk. 1894. Vol. 14, p. 398).

5. **Low Temperature and Boiling Point Thermometers.**

12. Julius Peters, Berlin N.W., 4 Thurmstr.

Maker of Philosophical and Technical Measuring Instruments.

(See also Sections Vb and Vd.)

Berthelot-Mahler's Calorimeter, after Dr. Kroeker's latest design, with apparatus for weighing the water due to hygroscopic adhesion and that resulting from the combustion. These calorimeters are supplied complete with all accessories.

Agents for Russia: Gebr. von Niessen, Berlin, 2 Hindersinstr.

13. C. Richter, Berlin N.W., 4 Thurmstr.

Maker of Philosophical Glass Instruments.

Thermometers ranging from —200° to +550°.

A. Standard Thermometers. These instruments can be determined fundamentally and are in themselves capable of calibration. The enlargements provided in the capillary tubes take up that portion of the mercury which has no share in the measurement of the temperature, and they may be exactly calibrated.

	Available for temperatures ranging from	to	Interval	
No. 1. Rod thermometer	— 5	+102°	0,1°	Jena boro-silicate glass. Graduation and lettering in indelible colours.
- 2. - -	— 5	+ 55°	0,1°	
- 3. - -	+ 45	+102°	0,1°	
- 4. - - Pernet's, adapted for variable quantities of mercury	— 40	+150°	0,1°	
- 5. Sealed-in thermometer	— 5	+102°	0,1°	Jena boro-silicate glass.
- 6. - -	— 35	+ 2°	0,2°	
- 7. - - standard for altitude measurements	+ 75	+102°	0,1°	
- 8. - -	+ 95	+155°	0,1°	
- 9. - -	+145	+205°	0,1°	
- 10. - -	+195	+255°	0,1°	

B. Thermometers for Laboratory and Industrial Purposes.

	from	to	Interval	
No. 11. A set, in which the range from 0 to 300° C. is distributed over three thermometers, each of which can be calibrated independently and determined fundamentally	— 10	+300°	0,5°	
- 12. A set, in which the range from 0 to 400° C. is distributed over four thermometers, each having the freezing point marked. The capillary tubes are filled with dry gas above the mercury	— 10	+400°	1°	
- 13. Beckmann's thermometer for variable quantities of mercury	— 40	+250°	0,01°	
- 14. Rod thermometer with freezing point filled with gas at a pressure of 20 Atm. absol.	+300	+550°	1°	
- 15. Kohlrausch's rod thermometer, filled with petroleum-aether	—170	+ 20°	1°	
- 16. Louguinine and Chappuis's rod thermometer, filled with toluol	—100	+ 50°	1°	
- 17. Mahlke's sealed-in thermometer, for correcting the exposed column	— 10	+300°	1°	Bulb 100 mm long
- 18. Mahlke's sealed-in thermometer, for correcting the exposed column	— 10	+300°	1°	- 200 - -

14. Siemens & Halske Limited, Berlin.

(See also Sections Va, VI and VII.)

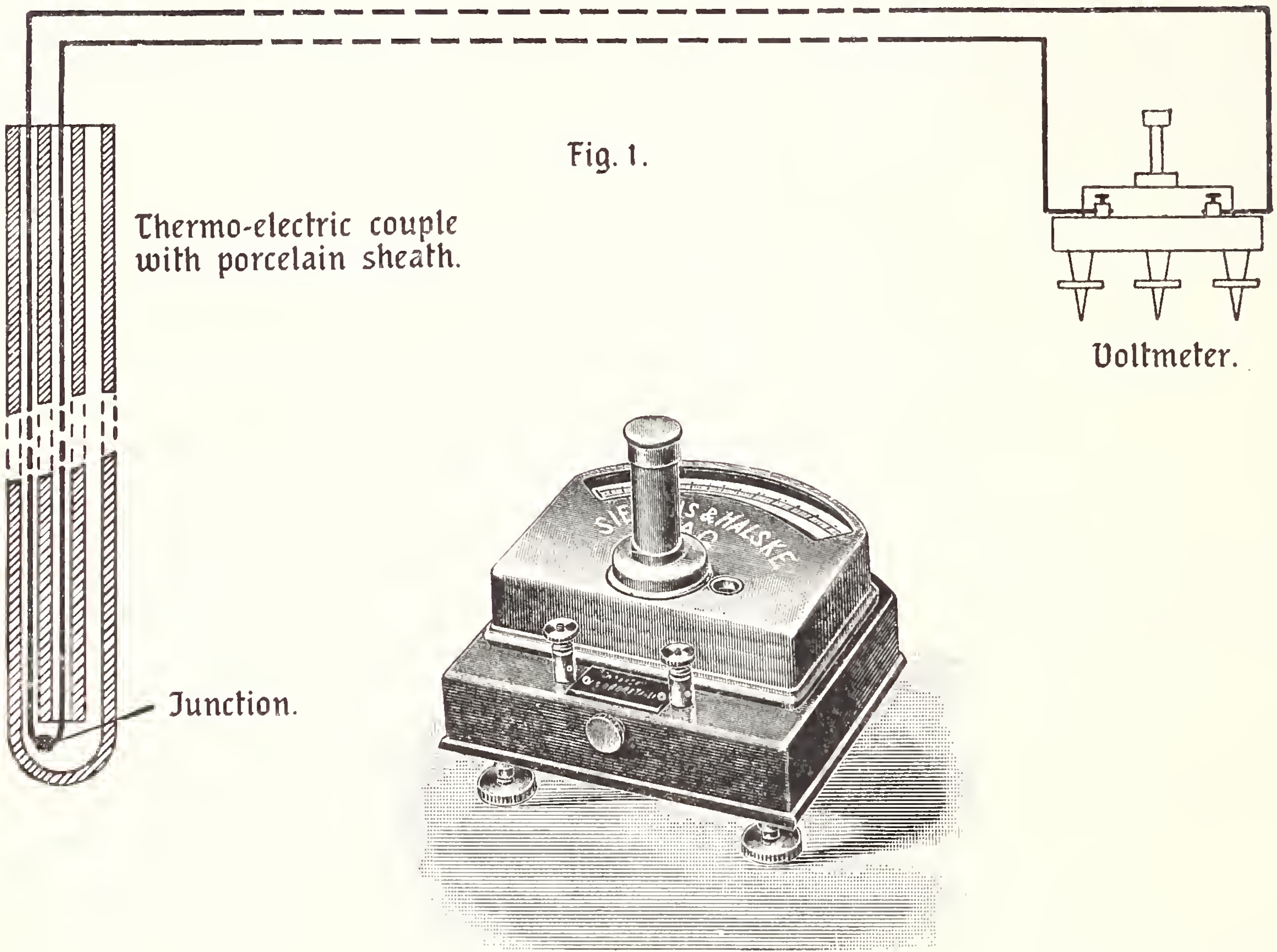


Fig. 1.

Fig. 2.

Pyrometer (Fig. 1) for measuring temperatures from 0 to 1,600° C., adapted for smelting, distilling, foundery work, &c., consisting of a sensitive and accurate millivoltmeter (Fig. 2) and a Le Chatelier platinum-rhodium thermo-electric couple, standardized by the Imperial Physical and Technical Institute, enclosed in a double sheath of Hecht's composition.

The voltmeter is of the Deprez-d'Arsonval type and has a movable suspended coil and a volt scale indicating from 0 to 0.018 volt, and a temperature scale, each division of which reads 10° C. Owing to its high internal resistance, which largely consists of manganine, the instrument may be set up at a considerable distance from the furnace without the necessity of making allowances for the resistance of the conducting wires or the temperature of the voltmeter.

15. Ludwig Tesdorpf, Stuttgart, 71 Forststr.

Maker of Scientific Instruments of Precision.

Speciality: Astronomical and Surveying Instruments.

(See also Sections IIIa and IIIb.)

Magnet Theodolite, after Prof. Eschenhagen, of Potsdam, constructed to meet the requirements of explorers. The horizontal limb has an opening of 12 cm, it can be rotated, and is divided on silver in $^1/_3$°, the divisions being read within 12" by reading microscopes.

A very sensitive magnetic declination needle consisting of four superposed flat steel laminae is provided with a small mirror at the end nearest the objective.

By means of an original device the magnet-needle can be fixed, reversed and replaced on its pivot within the metal casing surrounding it without opening the glass cover and without touching it with the fingers.

The horizontal inclinable telescope serves both for viewing objects in the field and for observing and adjusting the reflected image of the glass eyepiece micrometer which appears as vertical lines in the mirror attached to the horizontally oscillating needle. The angular differences resulting from each set of observations are read off the horizontal circle.

After detaching the compass, the understructure of the instrument serves as a basis for several accessories, such as the dipping needle, the oscillation box with its suspension tube for ascertaining the intensity of the tubular deviating magnets, a theodolite body (standard and altitude circle, &c.). The instrument case contains all the accessories and auxiliary tools required for the use of the instrument, also thermometers, magnets for re-magnetizing the dipping needle, &c.

16. O. Töpfer, Potsdam.

Maker of Philosophical Instruments.

Established 1873.

(See also Section II.)

Prof. Eschenhagen's Portable Registering Apparatus for Magnetic Observations consisting of a registering apparatus, a lantern and a series of variometers set up at various distances.

The rays reflected by the mirrors of the variometers are concentrated by lenses into fine luminous points and projected upon gelatino-bromide paper, surrounding the cylinder of the registering apparatus. This cylinder turns once in 2 or 24 hours, and the time is registered every 5 minutes or every hour accordingly.

The magnetometer, as constructed according to the experience gained from observations made at the Magnetic Observatory of Potsdam, possesses the following advantages: A double mirror attached to the magnet serves to expand the limits of registration; the mirror is readily adjustable; the magnet casing is easily accessible; the action of the copper damper is adjustable; each part, viz. the magnet case, suspension-tube, torsion-head, can be turned separately; the suspension can be clamped so as to minimise the risk of rupturing the suspending thread.

In order to obtain an intensity variometer, the bifilar suspension is replaced by a single thread, the magnet being placed at right angles to the magnetic meridian by turning the upper suspension. By suitably selecting the thickness of the thread, the degree of sensitiveness can be rendered more than 20 times greater than that of the usual instruments. A small revolving magnet attached to a rail serves for determining the degree of sensitiveness. The latter can be varied by means of an adjusting magnet placed below the magnetometer (see Sitzungsberichte der Deutschen Physikalischen Gesellschaft in Berlin, 1899, No. 9).

The magnetometer can be equipped with a scale-telescope of special construction, so as to render it available for ocular demonstrations.

Owing to the smallness of the magnets, the declination and intensity magnetometers (a vertical variometer is under consideration) can be set up within a small space. This mode of setting the instrument up is particularly adapted for the method of simultaneous observation proposed by Prof. Eschenhagen and adopted at the international congresses held at Paris 1896 and Bristol 1898, as well as for longer or shorter series of registrations of variations, such as are rendered desirable for the purposes of magnetic surveys.

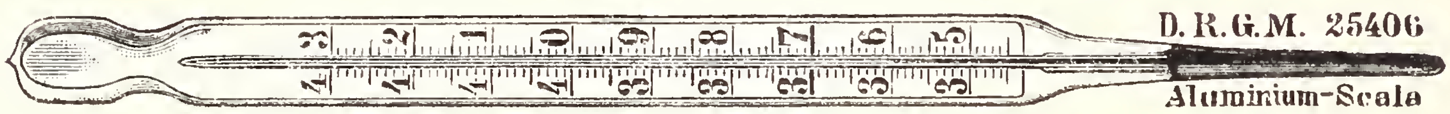
This instrument is the property of the Royal Magnetic Observatory of Potsdam.

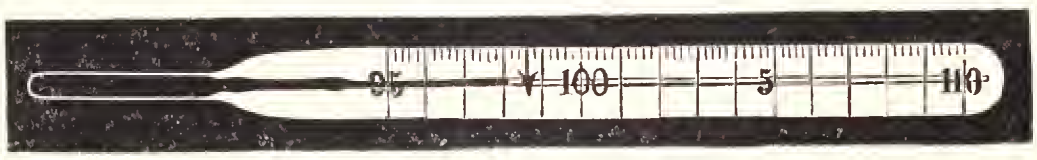
17. Wilhelm Uebe, Zerbst (Anhalt).

Manufacturer of Clinical and Chemical Thermometers.

Exporter of Thermometers of all kinds and Glass Nursing Implements.

Highest Awards at Universal Exhibitions. 2 Diplomas and 2 Medals at the Chicago World's Exhibition 1893.

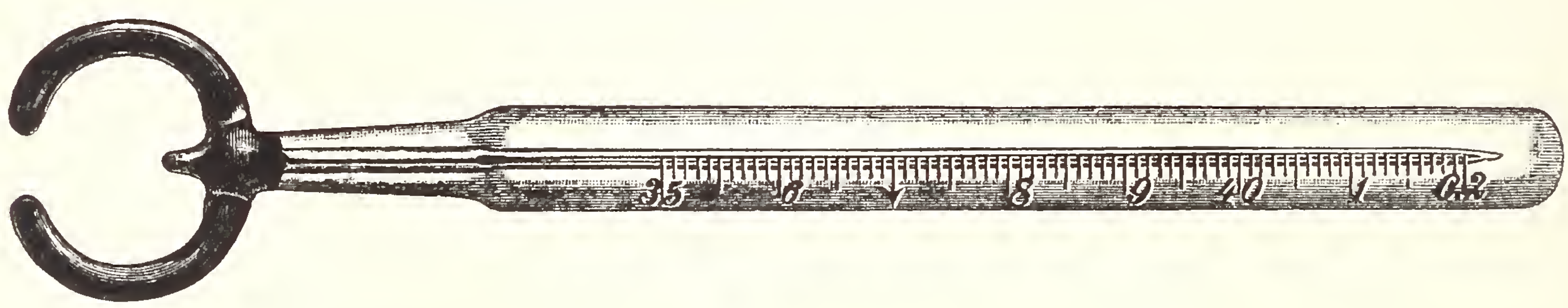




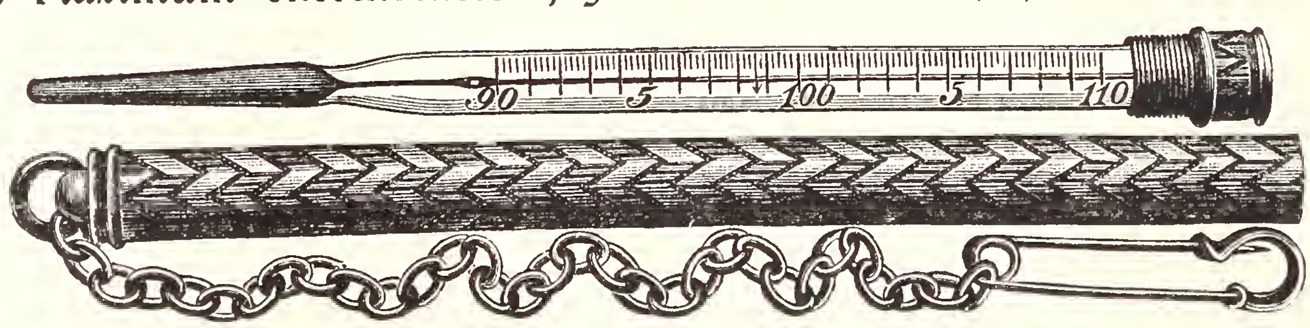
1. **Uebe's Minute Clinical Maximum Thermometer** with aluminium or mica scale, otherwise made entirely of Jena Normal Glass. Reg. in Germ. D. R. G. M. Nos. 25,406, 31,673, 84,289, 89,903. 18 cm, 13 cm and 10 cm long. These new Minute Maximum Thermometers possess the following advantages:—
   - a) The thermometer is without metal mountings, nickel or brass capsules, it being a well known fact that these offer no permanent protection; on the contrary, being apt to work loose during use or transport, especially when exported over sea, the risk of breakage is thereby increased.
   - b) The scale being under glass is not apt to be injured and become indistinct, as is the case with etched thermometers.
   - c) The thermometer, being hermetically sealed, can readily and completely be sterilized by any antiseptic fluid, and no difficulty can possibly arise from impurity or the penetration of the antiseptic fluid. They are supplied in a new form of antiseptic leather case.

All Uebe thermometers are supplied with certificates by the Imperial Physical and Technical Inotitute, or by the manufacturer. The tests are twofold and accurately conform to the requirements sf that Institute.

2. **Lingual Minute Thermometers.** Reg. in Germ. D. R. G. M. No. 5,576.



3. **Minute Maximum Thermometers,** graduated on the stem, 8, 10 and 12 cm long.



4. **New Minute Maximum Thermometer,** with blue enamel coating. Reg. in Germ. D. R. G. M. No. 56,496, very easy to read, the contrast between the enamel and mercury being very marked.

5. **Chemical Thermometers** with blue enamel markings. Reg. in Germ. D. R. G. M. Nr. 56,496. These thermometers possess the novel feature that the stem is coated with blue enamel, whereby the mercury column shows most distinctly by contrast and the process of reading is greatly facilitated

18. E. A. Zschau, Hamburg.

Neumayer's Magnetic Travelling Theodolite. This instrument is adapted for rapidly and accurately determining out-doors the magnetic declination and horizontal component of the terrestrial magnetic force. The telescope and magnetic casing are mounted in a similar manner to Lamont's instrument. The magnets are fitted with mirrors for adjustment and swing on points. Suspension by cocoon silk fibres has been avoided except in the apparatus designed for measurement by oscillation. After removing the magnet casing the oscillation box can be mounted upon a theodolite. The azimuthal circle has a radius of 80 mm and is divided into $^1/_6°$ reading by microscopes to 12". The declination magnet is reversible and two magnets are compounded into one. The magnets are 10 cm long and their centres are 2.5 cm apart. Collimation of the circle is accomplished either by direct sighting when the sun is low or by reflection when it is high. The horizontal intensity is determined by deviations at two distances in combination with the oscillatory method. The deviation rails can be unscrewed on either side when not required. The deviating magnets are 10 cm long and can be placed into rigid sliding bearings on each side of the rail. While determining the deviations the magnets are protected by aluminium casings fitted with thermometers for ascertaining the temperature of the magnets, and a smaller magnet is suspended within the casing; this magnet is 50 mm long and non-reversible. The deviations are produced in the usual manner and, after setting up the oscillation box, the oscillatory method is likewise followed in the customary manner. The travelling case is appropriately fitted and contains all necessary tools for re-sharpening blunted pins and for otherwise keeping the instrument in good order.

The apparatus is mounted on a simple travelling stand, and a leather case is supplied for use as a knapsack.

This instrument is the property of the Imperial Marine Observatory at Hamburg.

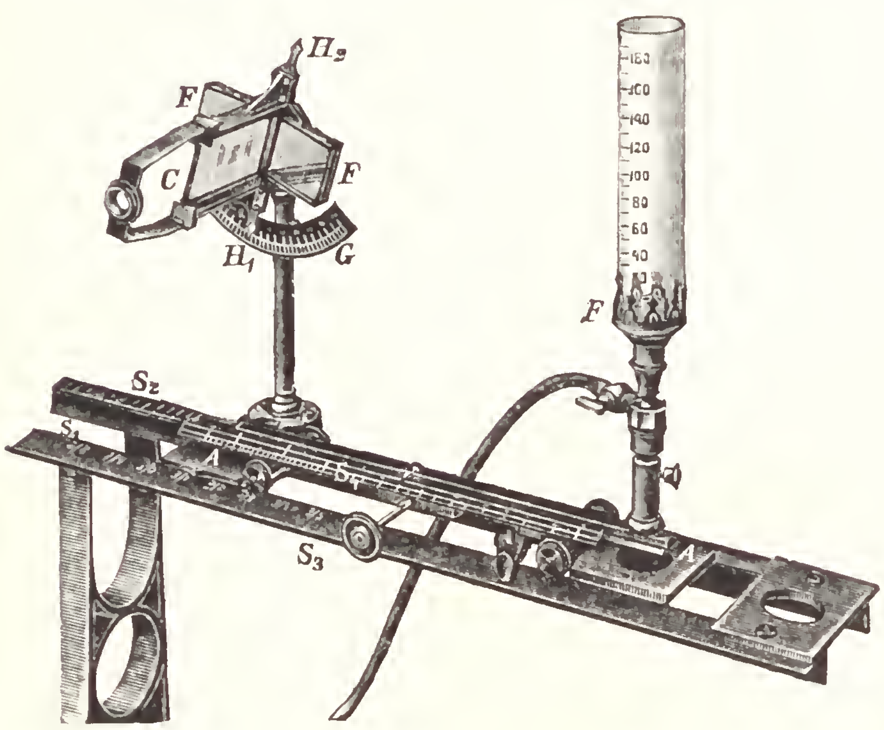
V. Optical Instruments.

a. Photometrical Appliances.

1. S. Elster, Berlin N.O. 43, 67/68 Neue Königstr.

Manufacturer of Gas Appliances.

1. Bunsen Photometer. This photometer serves for measuring horizontal rays and downward radiated light and consists of a stand 2.6 m long, the upper rails of which are provided with scales S_1, S_2 and S_3. The photometer-head F is made to rotate so as to measure light at certain angles. The inclination of the rays with respect to the horizon is shown by the pointers H_1 and H_2 on a scale G, and the slide A is placed upon the corresponding point of scale S_3. In addition, the distance of the standard flame E from the diaphragm C is variable, so as to admit of most accurate measurement with the aid of scale S_4.



2. Comparison Body. The usual paper diaphragm is suitably replaced by the comparison body supplied with this photometer for the purpose of measuring sources of light the colour tint of which resemble that of the standard flame. The comparison body consists of two parallel pieces of alabaster-glass separated by a reflecting plate of silver. It is extremely sensitive with respect to differences of colour and therefore particularly adapted for adjusting flames for a certain degree of combustion.

Descriptive price-lists may be had on application.

2. A. Krüss (Proprietor Dr. Hugo Krüss), Hamburg, 7 Adolphsbrücke.

Established 1796.

Optical Institute: Spectrum Apparatus, Prisms, Photometers, Projection Apparatus, Sciopticons, Lantern Slides.

(See also Sections Vb, Vd and VIII.)

1. Photometer Bench, 3 m long, with Lummer and Brodhun's photometer-head, fitted with telescope in a line with the axis (Journ. f. Gasbel. 1894. p. 61). Fig. 1.

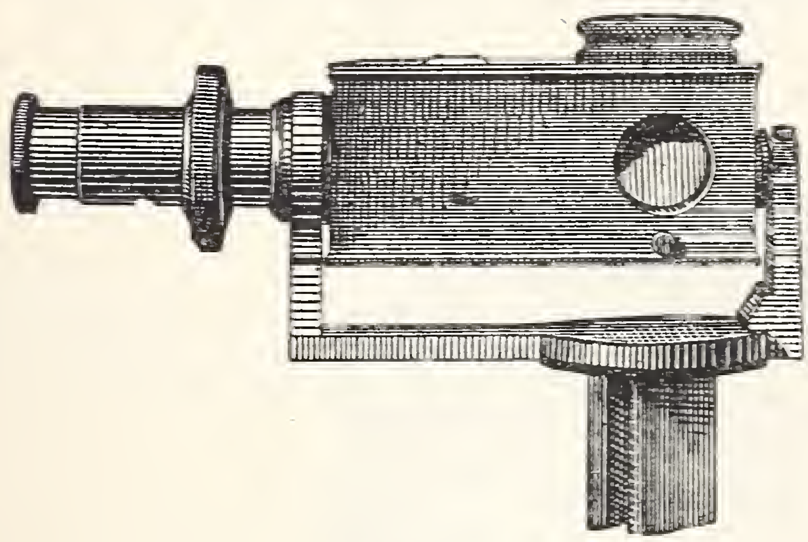


Fig. 1.

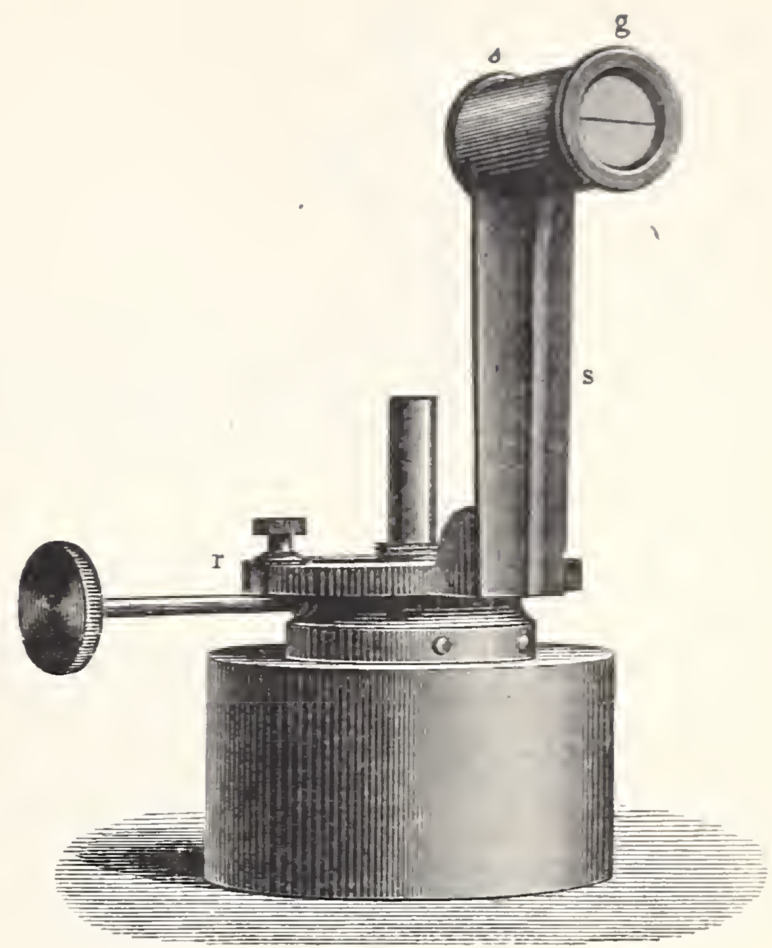


Fig. 2.

2. Hefner's Lamp with Krüss's Optical Flame-gauge including controlling gauge and trimmer. Certificated by the Imperial Physical and Technical Institute. Fig. 2.

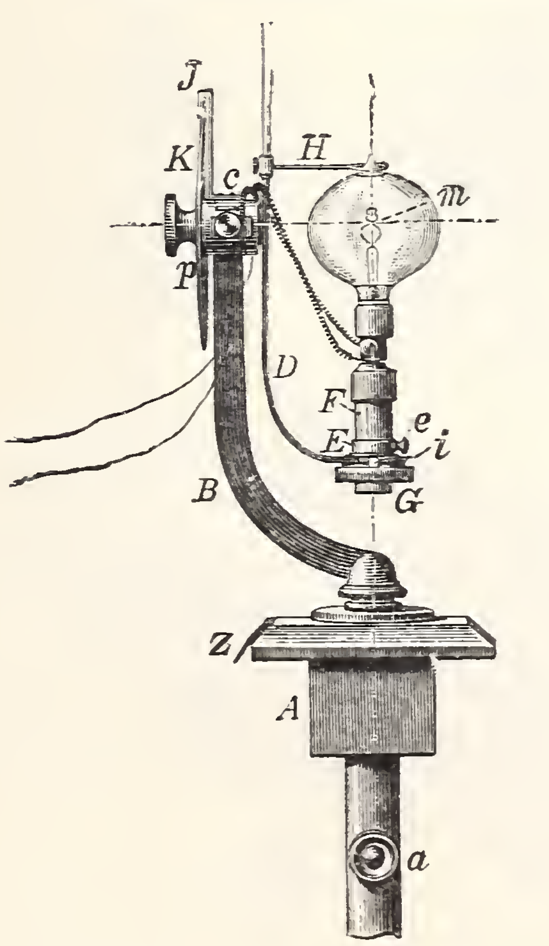


Fig. 3.

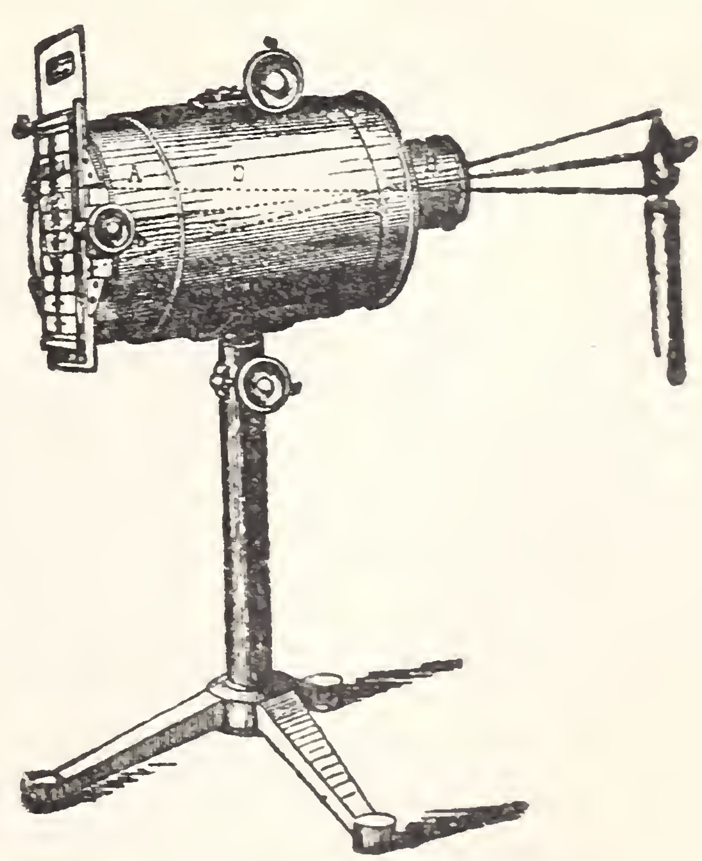


Fig. 4.

3. Photometer Stand for incandescent lamps. Fig. 3.

4. Krüss's Optical Flame-gauge. Fig. 4.

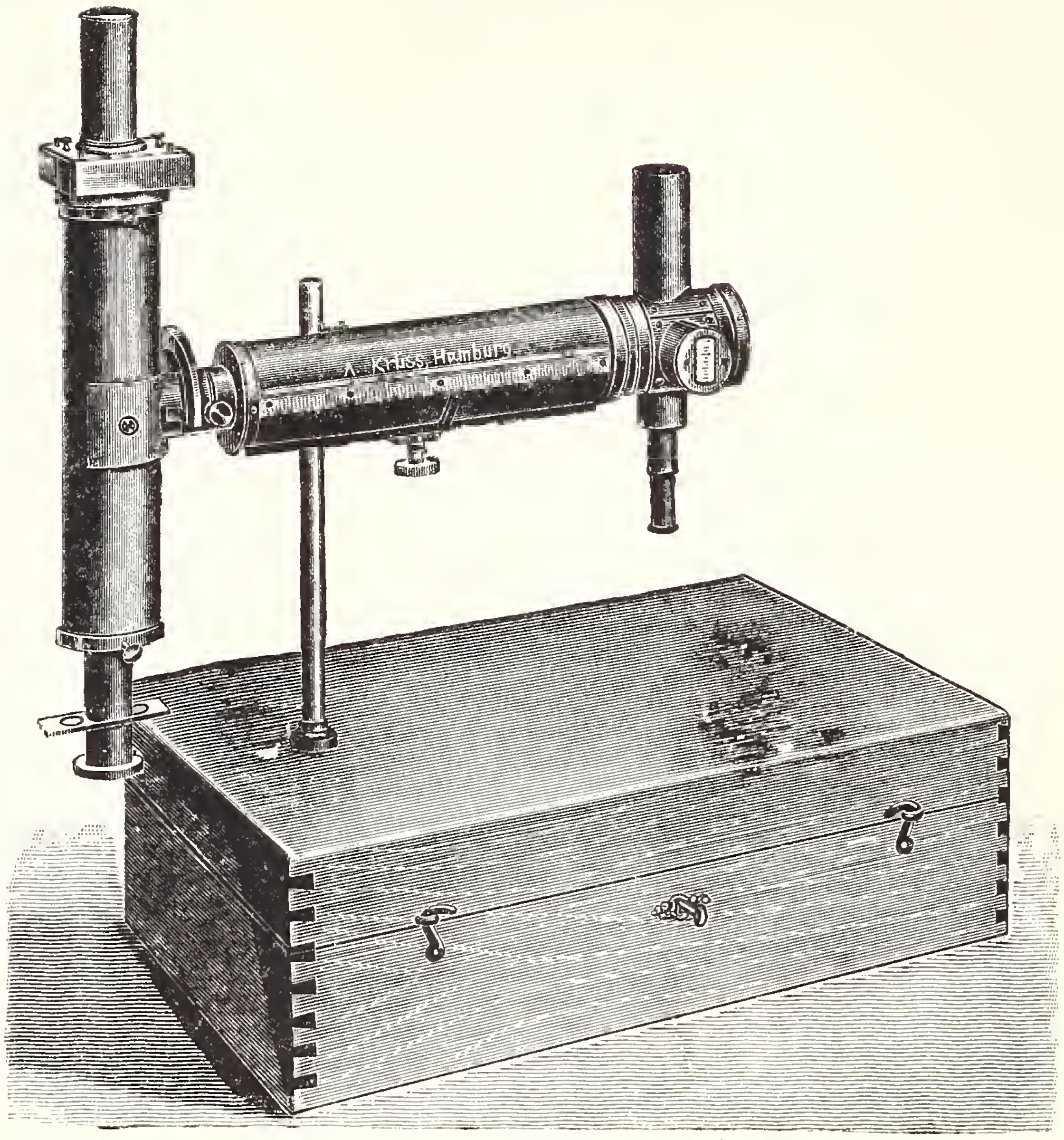


Fig. 5.

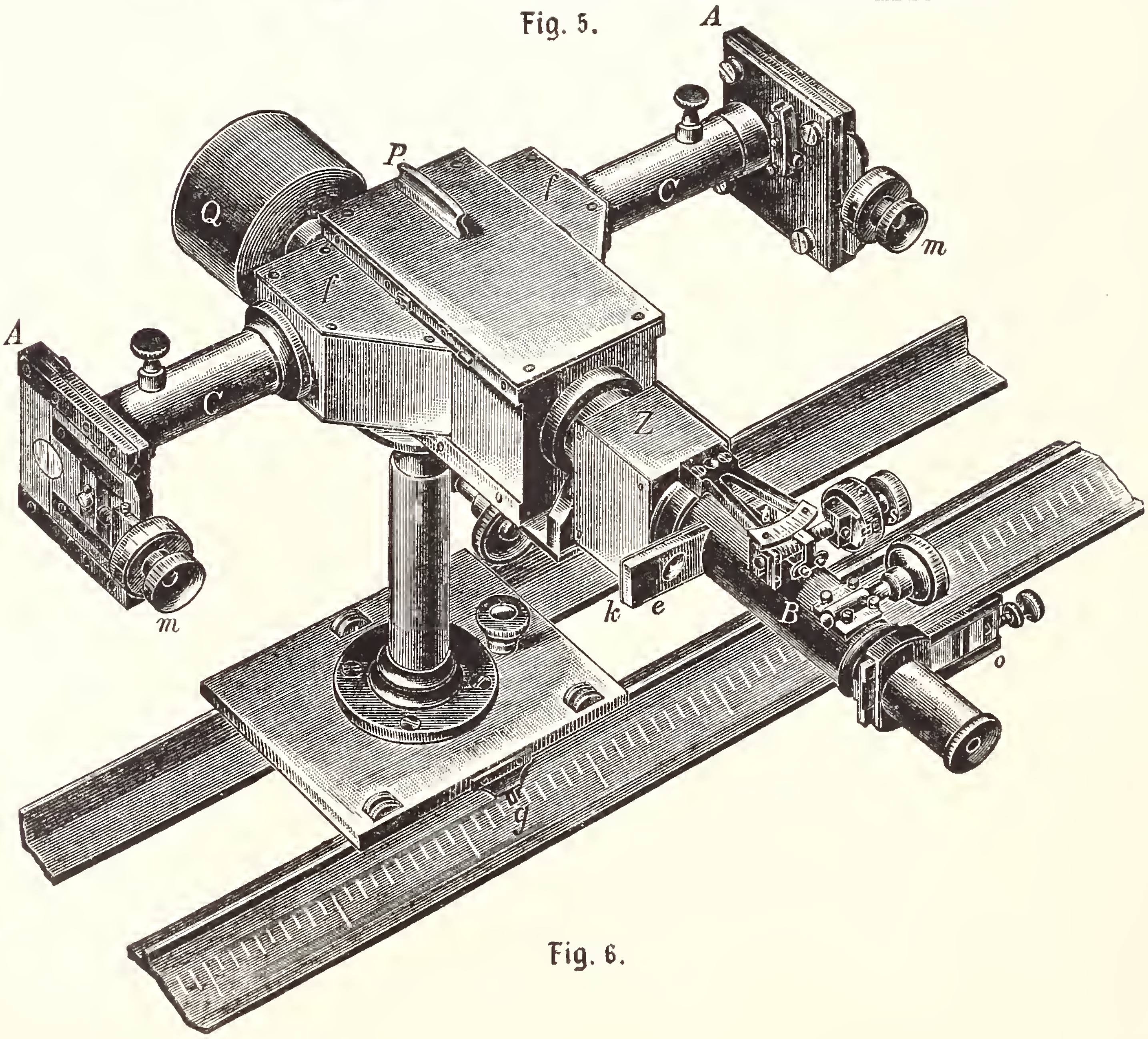


Fig. 6.

5. L. Weber's Photometer for determining the lighting power of luminants and the brightness of diffuse light, fitted with Lummer and Brodhun's prisms. Fig. 5.

6. Spectrum-photometer with Lummer and Brodhun's compound prism (own construction) with two symmetrical slits (Zeitschr. f. Instrumentenk. 18, p. 12. 1898). Fig. 6.

3. Fr. Schmidt & Haensch, Berlin S., 4 Stallschreiberstr.

Optical Works.

(See also Sections Vb, Vd and VIII.)

I. Spectrum Photometer.

Exhibits:—

1. Arthur König's Spectrum Photometer. New model, with telescope adapted for micrometric rotation about a horizontal axis. Fig. 1. This photometer is absolutely free from reflections, and

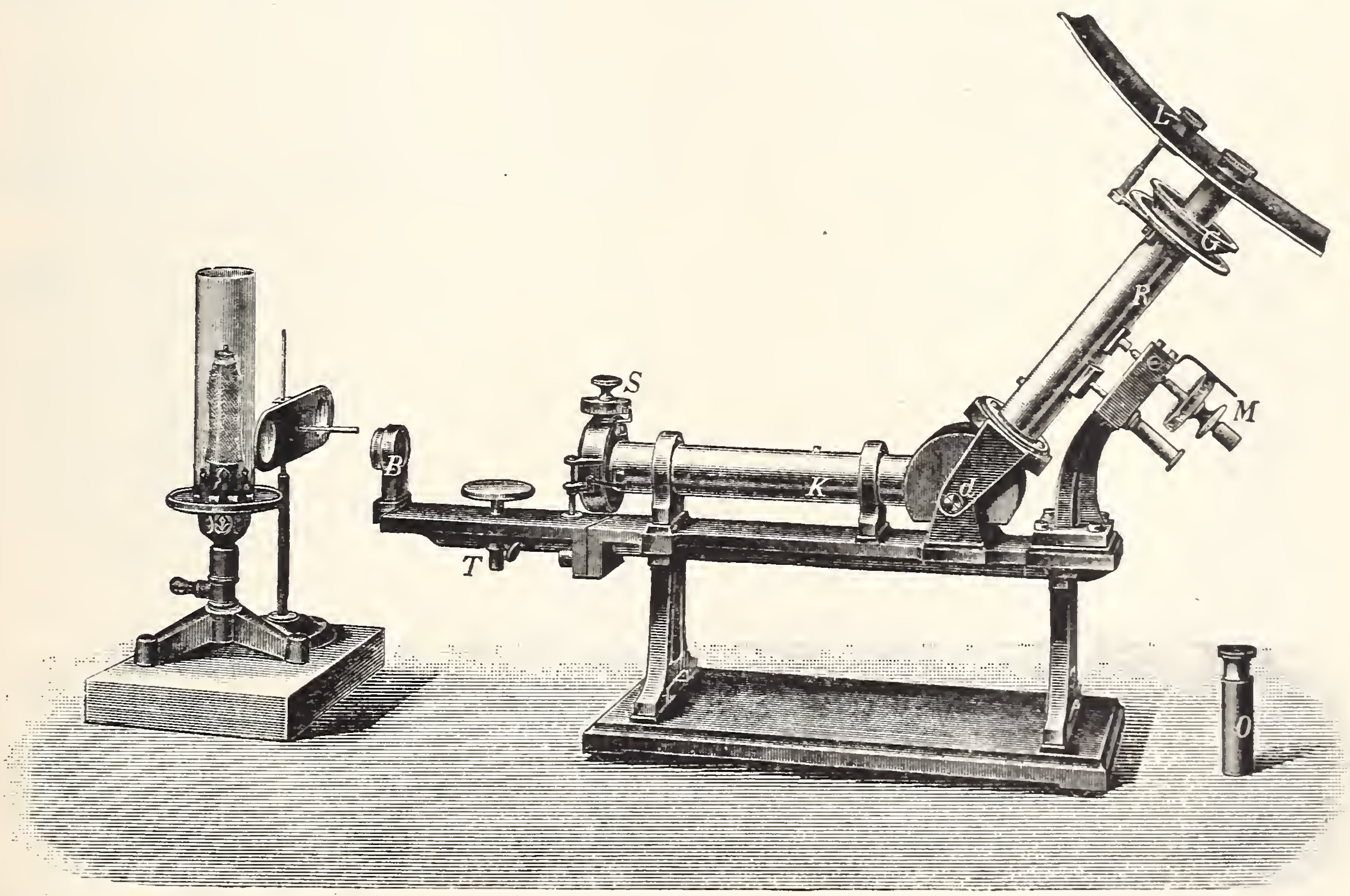


Fig. 1.

Arthur König's Spectrum Photometer. New model.

the line separating the comparison fields disappears completely when the intensities are equal in both, which materially affects the rapidity and precision of the adjustment. The measuring device takes the form of a Nicol prism.

2. Lummer and Brodhun's Spectrum Photometer fitted with two collimators placed at right angles to each other and Lummer and Brodhun's photometer cube.

3. **Brace's Spectrum Photometer.** Brace's flint prism consists of two cemented prisms and serves for dispersion as well as for the comparison of the pencils of light emerging from the collimators.

In Nos. 2 and 3 the light entering one of the collimators is moderated to a measurable extent by altering the width of the slit or by means of an adjustable sector which is either made to rotate while the rays pass straight through it or remains stationary while the rays rotate (see No. 7).

II. Stationary Photometers for White Light.

These appliances are fitted with a measuring device based upon the law of inverse squares.

4. **Photometer Benches.**
   a) Simple pattern.
   b) Large pattern,[2] with three carriages travelling on two steel tubes; on one of the tubes 250 cm are divided into millimetres or in terms of intensity units by quadratic progression.
5. **Comparison Appliances for photometer benches.**
   a) Simple apparatus fitted with Martens's[1] twin prism.
   b) Lummer and Brodhun's photometer head with concentric comparison fields, for measurement by the method of equal intensities.
   c) Lummer and Brodhun's photometer for measurement by the methods of equal intensities and equal contrasts.[2]
   d) Lummer and Brodhun's contrast photometer capable of rotation through a measurable angle about an axis at right angles to the optical bench.
6. **Appliances for photometrically testing incandescent lamps.**
   a) Two stationary mirrors including an angle of 120°.
   b) Apparatus consisting of two rotating mirrors.

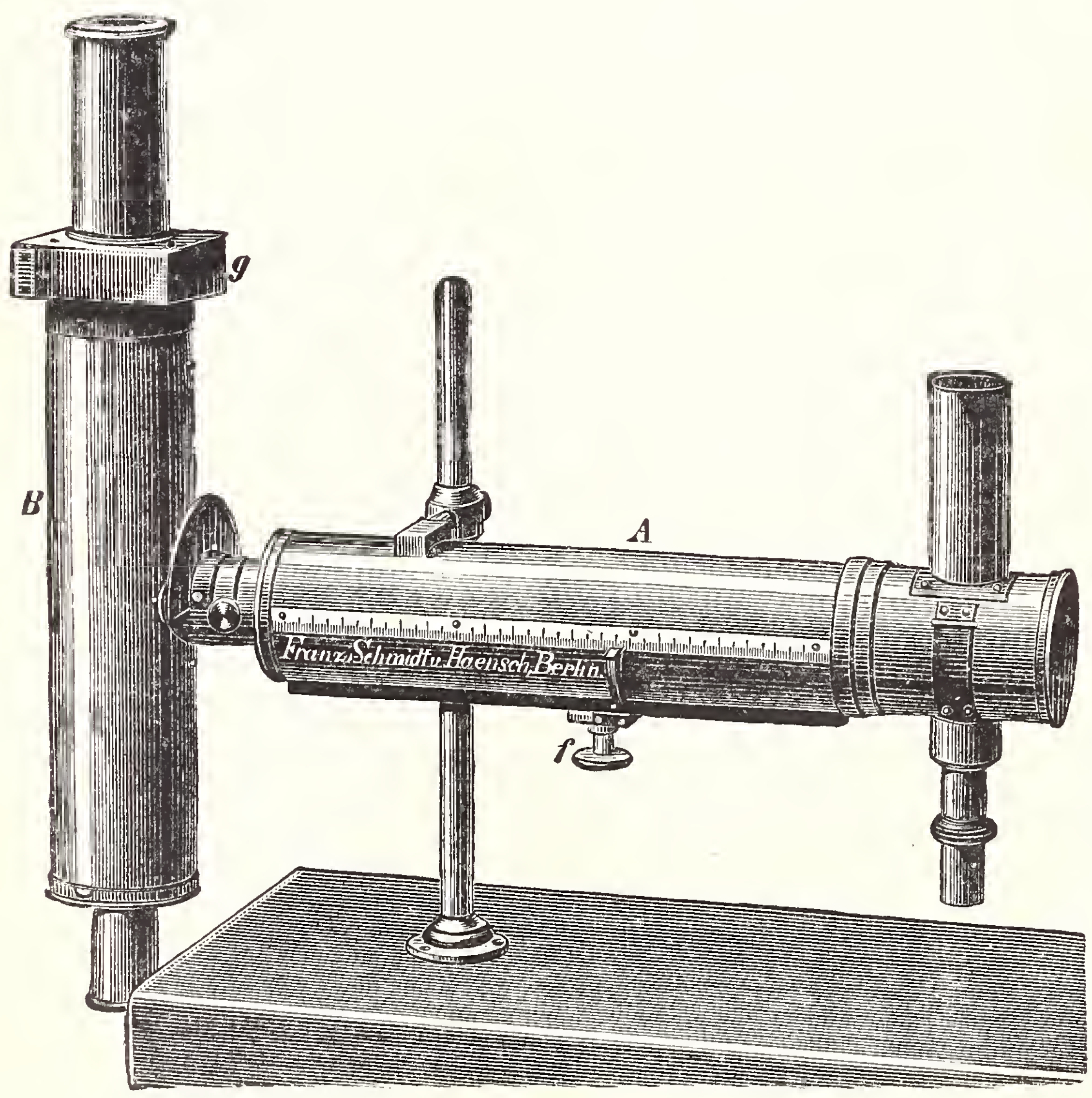


Fig. 2.
Weber's Photometer.

III. Portable Photometers for White Light.

7. **Brodhun's Street Photometer**[2] fitted with Lummer and Brodhun's photometer cube, specially adapted for the photometry of street lights, with two lamp casings for incandescent lamps or benzine candles. The photometer gauge takes the form of a sector of variable size; its novel feature consists in that the sector is stationary, while the rays of light are made to rotate.

8. **Leonhard Weber's Photometer** fitted with Lummer and Brodhun's cube, with table showing constants. Fig. 2. This photometer is portable and serves: 1. for measuring the luminosity or intensity of luminants in terms of Hefner candles; 2. for measuring in terms of meter-candles the degree of illumination or the indicated brightness of planes illuminated by a luminant of any description; it is equally well adapted for technical and hygienic purposes.

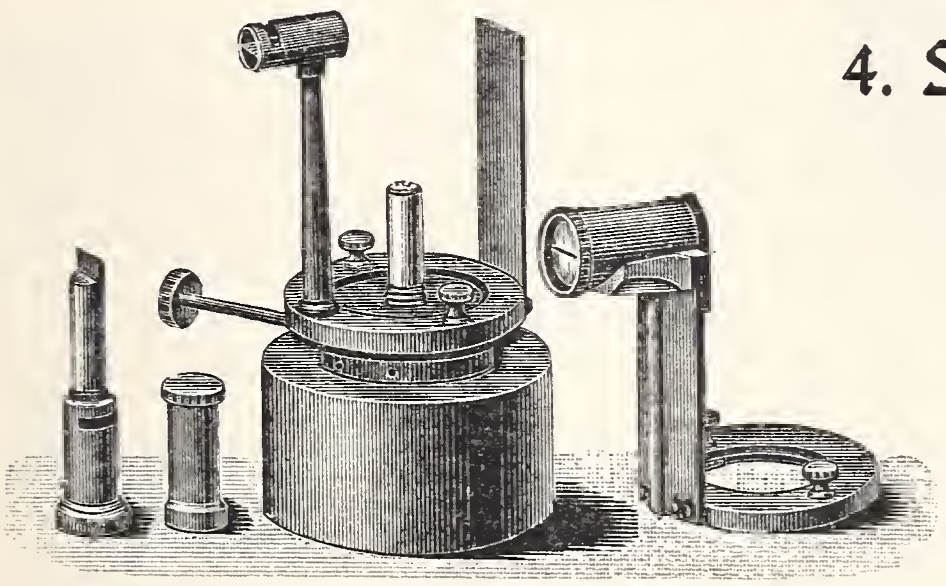
9. **Martens's New Polarizing Photometer** for white light. The two pencils of light which are

[1] Scientific optician of the firm.
[2] The appliances marked [2] are included among the exhibits of the Imperial Physical and Technical Institute (see under that heading).

to be compared with each other enter the photometer through two openings a and b and pass successively through an objective, a double refracting Wollaston calc-spar prism, a twin prism with its halves 1 and 2, an analyzing Nicol prism, a Ramsden eyepiece and the central aperture of a diaphragm. The experimenter sees fields 1 and 2 respectively filled with light entering through the slits a and b respectively. The measurements described under No. 8 are made with the aid of a small incandescent lamp supplied by a current of constant strength.

The entire photometer can be turned within a measurable angle round its longitudinal axis, round another axis, horizontal and at right angles to it, and round a vertical axis.

The most important application of this photometer is probably the examination of the intensity of completely or partly polarized parallel light, such as is emitted by the sky.



4. Siemens & Halske Limited, Berlin.

(See also Sections IV, VI and VII.)

Hefner Standard Lamp for photometric measurements, standardized by the Imperial Physical and Technical Institute, combined with Hefner's and Krüss's flame-scale, with gauge for the latter and the wick-tube.

b. Spectroscopes and Optical Measuring Instruments.

1. R. Fuess, late J. G. Greiner jr. & Geissler,

Steglitz near Berlin, 7/8 Düntherstr.

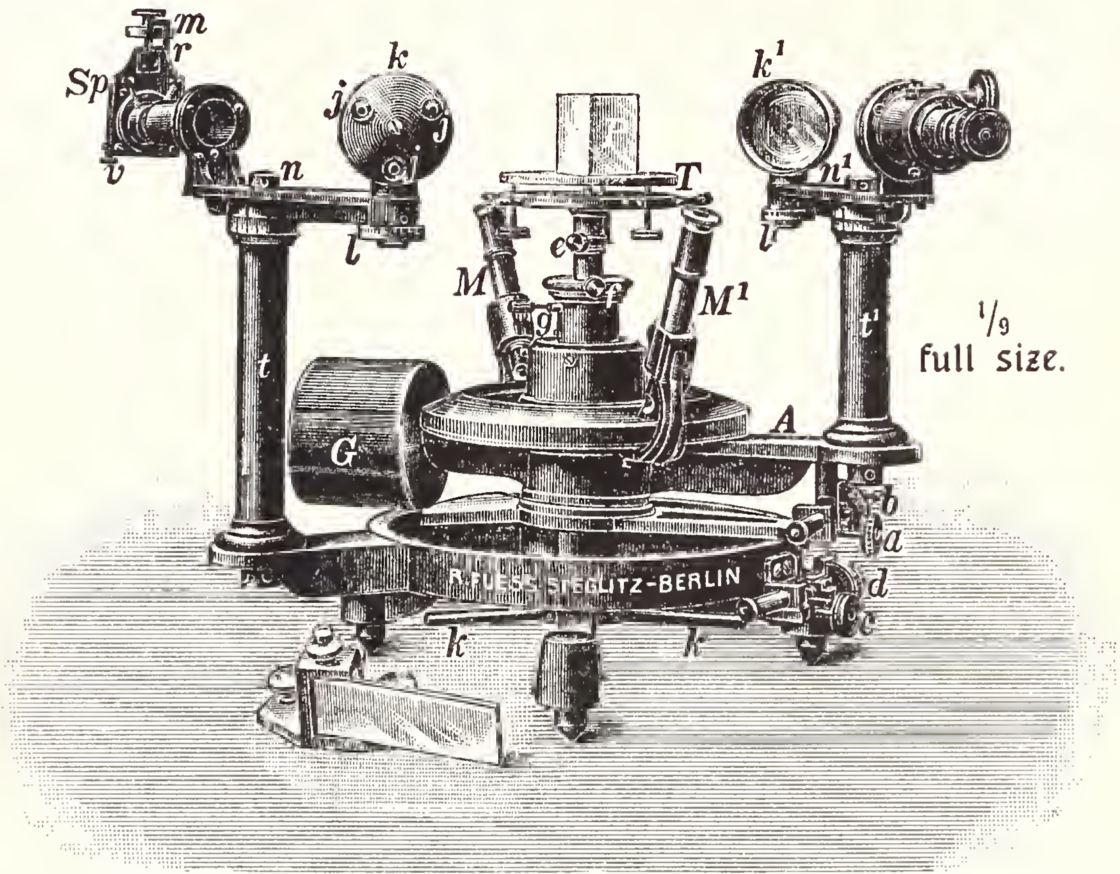
Mechanical and Optical Works.

(See also Sections IIIa, IV, Vd and Vg.)

1. **New Spectrometer** (see Fig. 1) fitted with Rubens's telescopes and mirrors. (See chapter on Spectrometers, C. Leiss, Die optischen Instrumente, &c. p. 1).

2. **V. Schumann's Quartz-spectrograph**, intermediate model. The objective lens has a focus of 400 mm for the sodium line. The camera objective and slit are adjustable by a rack and pinion movement. The draw-tubes are graduated in millimetres. Diaphragms fit in front of the objectives and their apertures can be read off in millimetres. The slit is formed by hard steel cheeks and can be adjusted by a micrometer-screw within $^1/_{1000}$ mm. In front of the slit there is a detachable wheel-diaphragm with square apertures for coincident photographs. The wheel-diaphragm has also an opening coincident with the full aperture of the slit and another opening containing a film of uranium glass. The dark slide is adapted for 4.5×12 cm plates. One half of the focussing screen is ground glass, the other uranium glass, so as to focus at the same time the red and violet parts of the spectrum. The dark slide is fitted with a screw and divided drum for taking a successive series of photographs one above the other, the mean position being shown by a pointer. The frame for the dark-slide turns about a vertical axis, a divided circle indicating the amount of the rotation. The axis of rotation produced coincides with the coating of the photographic plate. Without this means of slanting the photo-

graphic plate, it would be impossible to photograph with uniform sharpness an extended region of the spectrum. The body of the camera can be placed at any desired angle to the slit collimator, and its position reads off to 5' by a graduated circle. The prism stage is provided with a divided circle, it rotates independently and can be connected by a dark chamber with the objectives so as to exclude all light; consequently the whole of the spectro-photographic work can be carried out in a lighted room. (See chapter on Spectrographic Appliances, C. Leiss, ibid., p. 62, and plates I and II.)



1/9 full size.

3. E. A. Wülfing's Spectrum Apparatus, adapted for illumination by light of varying wave-lengths. This apparatus can be used in conjunction with any optical instrument, such as spectrometers, goniometers, polarizers, appliances for measuring circular polarization and microscopes. (C. Leiss, ibid., p. 25.)

4. V. Schumann's Universal Sparking Apparatus, fitted with devices to cause the spark to pass either along or at right angles to the slit and adapted for the use of transverse and longitudinal discharging tubes (C. Leiss, ibid., p. 93).

5. V. Schumann's Sparking Apparatus. The spark traverses the slit at right angles (C. Leiss, ibid., p. 92).

6. Direct vision Fluid Prism.

7. New Crystal Refractometer, Model II. This instrument has been designed with the primary object of rendering it available for the examination of small and defective surfaces of crystals and mineral particles contained in microscopical preparations. The instrument is equipped with a patented light-excluding casing, which admits of its use in a lighted room. By this means, the refractometric investigation, especially if it relate to petrography, can be carried out in alternation with the microscopic examination. The light-excluding casing being readily detachable, observations may be made with the additional aid of a universal mirror, both after the method of grazing incidence and that of reflection. In addition, this new device forms a permanent protection of the hemisphere from external injuries.

The vertical circle is divided into $^1/_2°$ and reads 1' by a vernier. The horizontal circle is divided into single degrees. The former is adjustable by a micrometer-screw with a divided drum for measuring dispersion and small degrees of double refraction. One interval reads 10". (C. Leiss, ibid., pp. 45 and 363.)—Tables for determining the refractive indices from the readings of the divided circles will be found in C. Leiss, ibid., pp. 363-367.

8. Refractoscope for demonstrating the curves of intersecting index surfaces and those of intersecting surfaces of rays. The phenomena demonstrated by this apparatus with the aid of an incandescent gas lamp are so intense as to be visible to a large audience in a moderately dark room (C. Leiss, ibid., p. 49, Figs. 31-33 and p. 345, Figs. 210 and 211).

9. New Fluid Refractometer, with J. F. Eykman's heating apparatus (C. Leiss, ibid., p. 370). Tables for determining the refractive indices from the readings of the divided circles will be found in C. Leiss, ibid., p. 382.

10. Polarizing Apparatus for parallel and converging light.

11. Polarizing Prisms of various forms.

12. Polarizing Prism, consisting of glass and calc-spar combined. Registered in Germany (C. Leiss, ibid., p. 154).

13. Polarizing Prism after Jamin, with calcite film and a highly refracting fluid. Registered in Germany.

14. A. M. Mayer's Clock-driven Heliostat. (See chapter on Heliostats, C. Leiss, ibid., p. 284.)

15. Reading Telescope.

2. Bernhard Halle, Steglitz near Berlin.

Optical Works.

Speciality: Optical Preparations for the Polarization of Light.

A. Preparations of Iceland Double Spar.

1. A Nicol with oblique faces, rhomboid.
2. - - - - - square section.
3. - - - orthogonal - (Hartnack-Prazmowsky).
4. - - - - - (Glan-Thompson).
5. - - after Foucault.
6. - - - Glan.
7. - Sphere.
8. - Double Refracting Prism.

9. An Original Method of preparing Nicol prisms with perpendicular faces. This method is adapted for manufacture in large numbers and has besides over the older process the advantage of greater accuracy, both as regards the quality of the surface and the exactness of the angles, so as to entirely obviate a displacement and distortion of the image.

The exhibitor has also constructed a sawing machine for cutting the Iceland spar. The form of this machine is shown in a photograph.

B. Preparations of Pebble.

10. A Prism having its refracting edge at right angles to the axis.
11. - Cornu Double Prism.
12. - Babinet Compensator consisting of two wedges.
13. - Soleil Compensator (two wedges and a compensating plate).
14. - Wedge, parallel to the axis, I. to III. order.
15. - Bertrand Quadruple Quartz-plate.

C. Preparations of Glass.

16. A Rectangular Prism.
17. - Rutherford Prism.
18. - Plano-parallel Plate.

3. Gustav Halle, Rixdorf near Berlin, 53 Hermannstr.

Maker of Scientific and Technical Instruments of Precision.

(See also Sections Vc, Vg and X.)

1. **Large Universal Heliostat adjustable for any polar altitude,** with an exceptionally strong understructure and a reflecting mirror having a surface of 700 qcm, and adjustable in height by means of rack and pinion. The hour circle has a diameter of 120 mm, it is divided at intervals of 2 minutes, and half-minutes can without difficulty be estimated with the aid of a magnifier adjustable for individual sights (supplied with the instrument). The levelling screws of the stand are protected by dust-sleeves. The clock-work is carefully regulated and fitted with cylinder action.

2. **Small Universal (College) Heliostat adjustable for any polar altitude.** Its mirror has a surface of 225 qcm, it is adjustable for height, the hour circle has a diameter of 80 mm. The levelling screws in the tripod are protected by dust-sleeves. The clock is of the cylinder type.

4. A. Krüss (Proprietor Dr. Hugo Krüss), Hamburg,

7 Adolphsbrücke.

Established 1796.

Optical Institute: Spectrum Apparatus, Prisms, Photometers, Projection Apparatus, Sciopticons, Lantern Slides.

(See also Sections Va, Vd and VIII.)

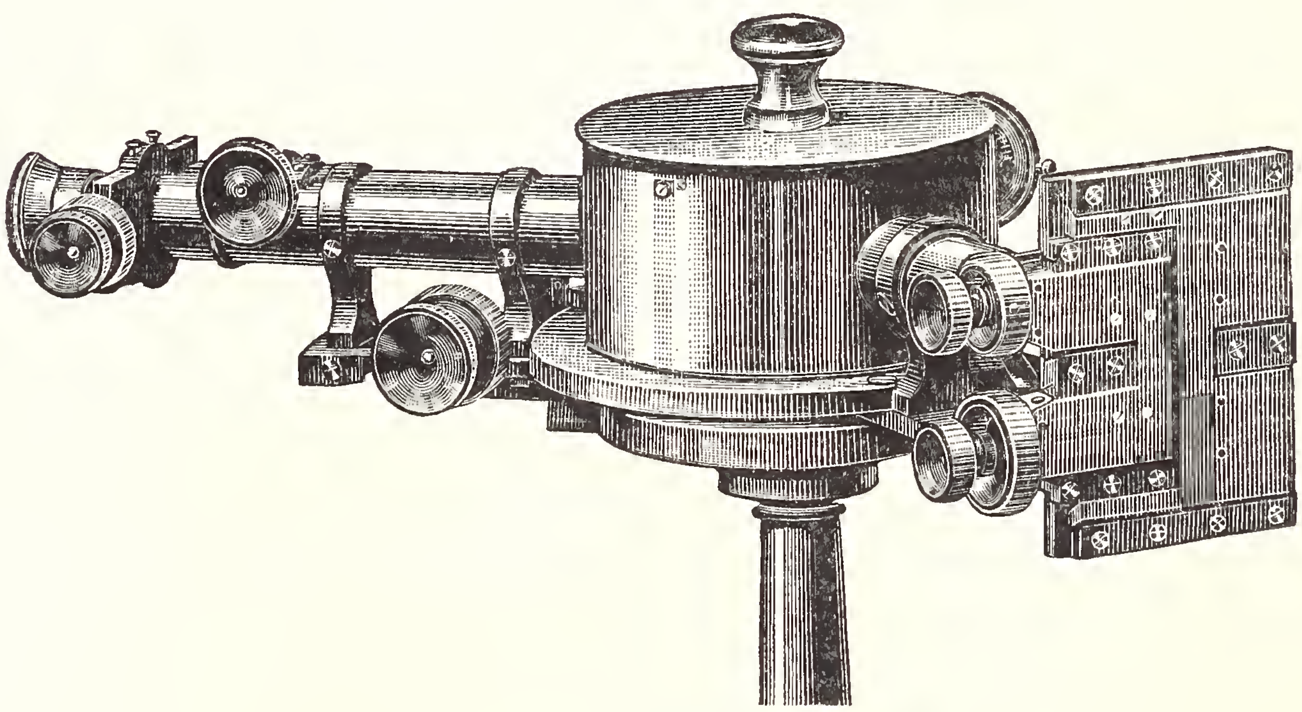


Fig. 1.

1. **Universal Spectrum Apparatus,** original construction, for spectrum photometry, qualitative and quantitative analysis, fitted with symmetrical slits. Fig. 1.

2. **Spectrum Apparatus** with six automatically adjustable prisms, of original construction. Dispersion 32°. (Zeitschr. f. Instrumentenk., 10. p. 97. 1890.) Fig. 2.

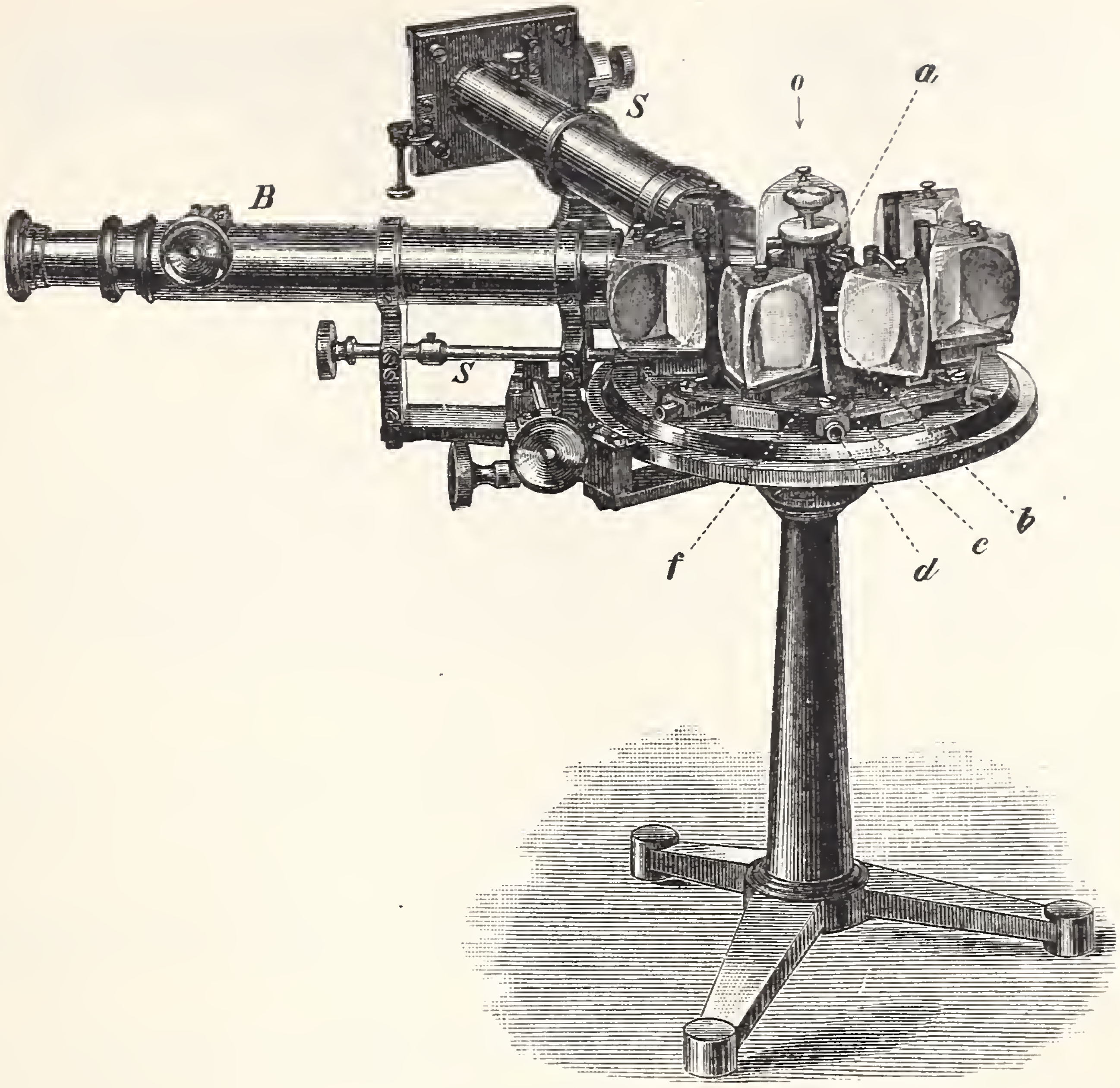


Fig. 2.

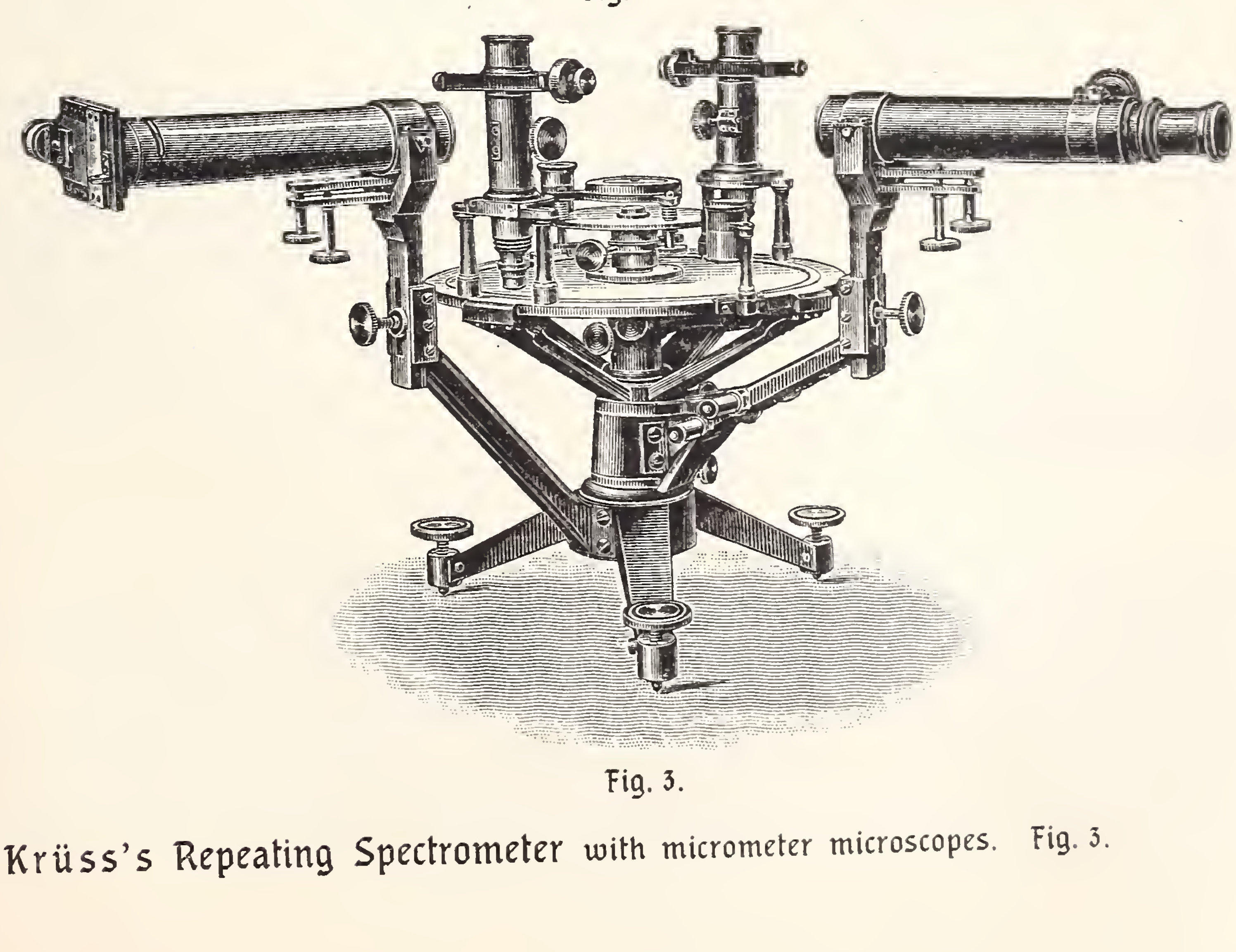


Fig. 3.

3. **Krüss's Repeating Spectrometer** with micrometer microscopes. Fig. 3.

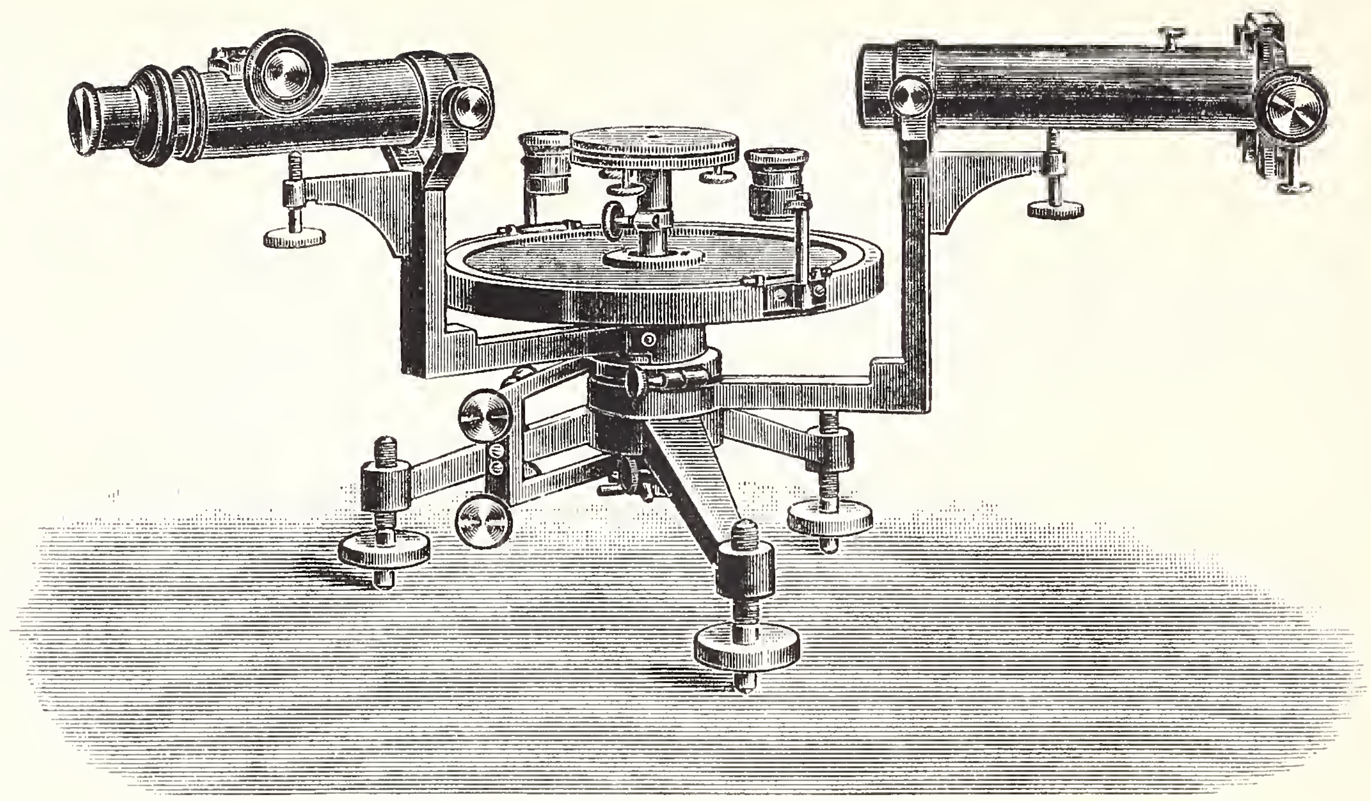


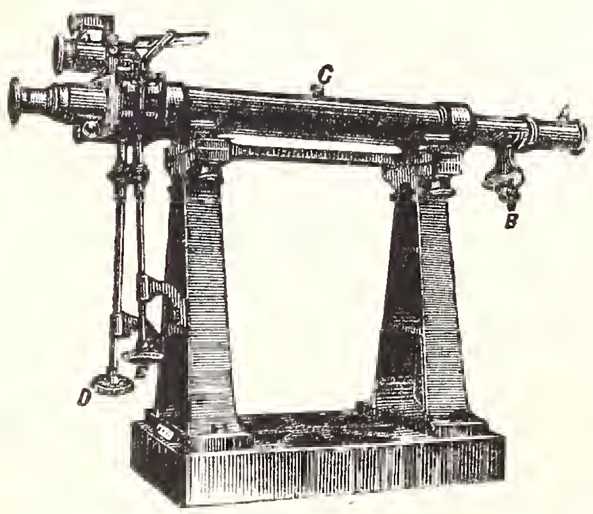
Fig. 4.

4. V. v. Lang's Spectrometer. Circle 170 mm in diameter, reading 30" by magnifiers. Fig. 4.
5. Browning's Spectroscope.
6. H. W. Vogel's Spectroscope.

5. Julius Peters, Berlin N.W., 4 Thurmstr.

Maker of Philosophical and Technical Measuring Instruments.

(See also Section IV.)



1. Polarizing Apparatus with divided circles (for homogeneous light) for scientific and general purposes, after Mitscherlich, Laurent, Lippich and Landolt.

2. Polarizing Apparatus with compensating quartz wedges (for white light) specially designed for the purposes of sugar-refiners, agricultural laboratories and customs inspectors after Soleil-Ventzke, Herzfeld and Stammer; also instruments of original design with various patented improvements. The latter instruments possess certain optical advantages which render them, as universally acknowledged, extremely sensitive. The mean error of adjustment is less than $\pm 0.02°$ Ventzke.

3. Polarizing Accessories.

New Appliances.

Polarizing Apparatus with Magnifying Scale from 0 to 25 degrees for determining the percentage of sugar in beet-root. Reg. in Germ. D.R.G.M. No. 117,196.

Polarizing Apparatus having its quartz wedges mounted without pressure, which obviates the disadvantages resulting from the usual way of mounting, which by unequal pressure or changes of temperature is apt to interfere with the optical image and thus to lead to errors of observation. German patent No. 103,199. (These instruments are described as "Standard Polariscopes.")

General Export Agent for England and outside Europe: Geo. Stade, Berlin (B.P.A.) C. 2; for Russia: A. Bukowinski & F. Slaski, Kiew, Gebr. von Niessen, Berlin, 2 Hindersinstr.

6. Fr. Schmidt & Haensch, Berlin S., 4 Stallschreiberstr.

Optical Works.

(See also Sections Va, Vd and VIII.)

I. Polarizing Appliances and Saccharimeters.

The general optical arrangement of these instruments is shown diagrammatically in Fig. 1. The diaphragm A' and the illuminating lens K supply the necessary illumination. The Nicol prisms N_1 and N_2 and diaphragm D form parts of the polarizer proper; the diaphragm A, the Nicol prism N_3 together with the small astronomical telescope O R, which can be adjusted so as to have D in focus, constitute the analyzer and measuring apparatus.

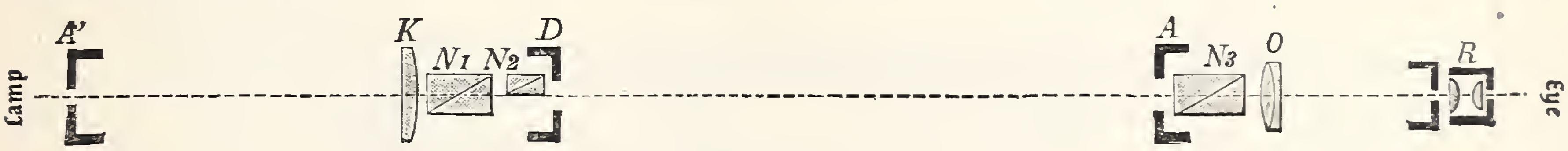


Fig. 1.
Polarizing apparatus.

In the polariscopes fitted with divided circles the Nicol prism N_3 is turned through a determinable angle corresponding to the rotatory power of the substance until both halves of the field appear illuminated to the same degree. The light used should be monochromatic.

In the instruments fitted with wedge compensators (saccharimeters) the rotatory power of the substance is compensated by the rotation, in the opposite sense, of a quartz plate of variable thickness. White lamplight should be used for the illumination.

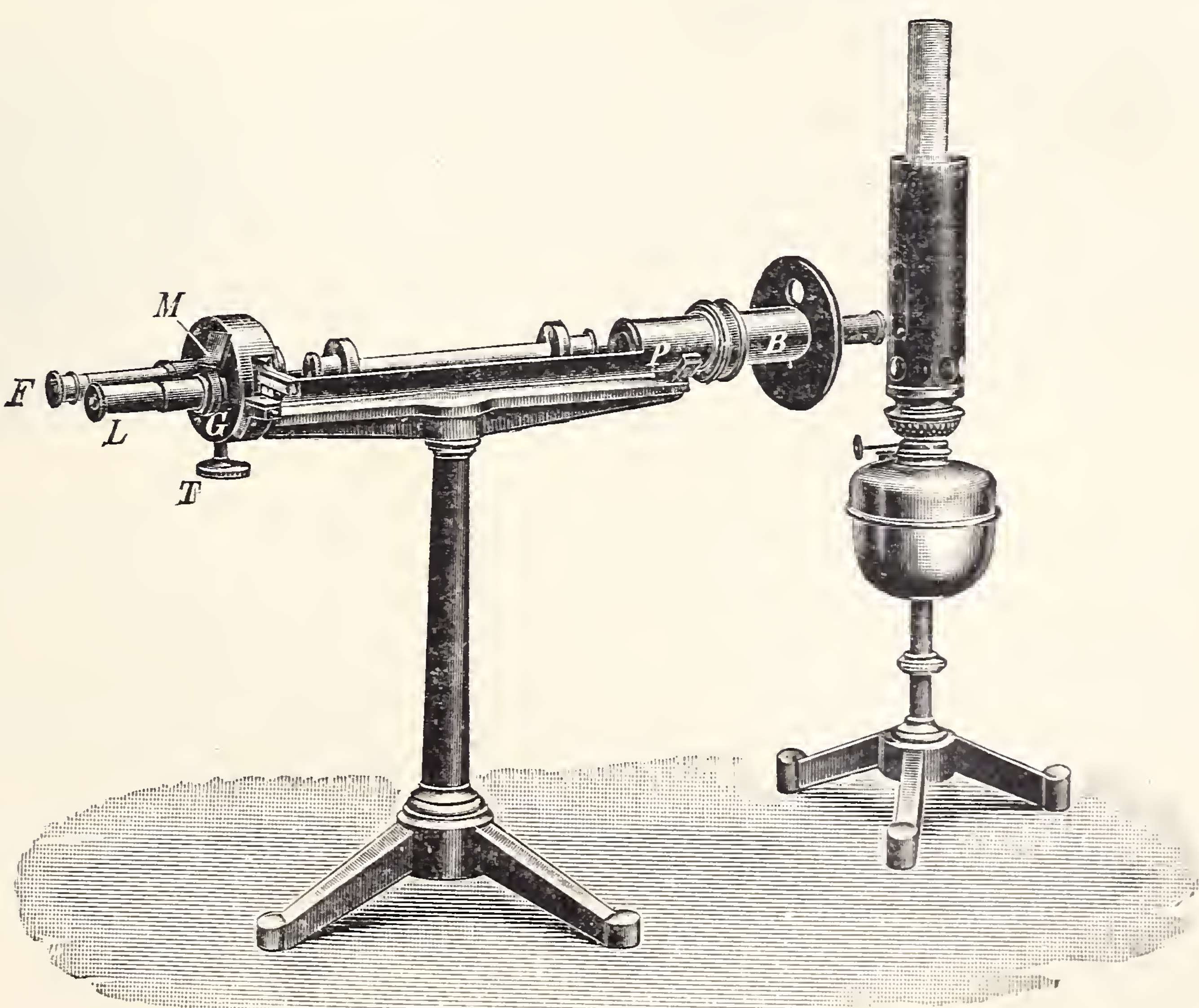


Fig. 2.
Saccharimeter with limited measuring range.

The exhibits include:

1. **Illuminating Appliances for saccharimeters.** a. Diaphragm tube with screening disk (B in Fig. 2 and Fig. 4. D. R. G. M. 100,892); b. illuminating apparatus with small incandescent light and scale illuminating mirror (V in Fig. 3. D. R. G. M. 100,891); c. trough with potassium bichromate solution, adaptable to a. or b.

2. **Lamps for white light.** a. Small incandescent lamp requiring 6 volts and 0.5 ampère, suitably supplied by three accumulators; b. small incandescent gas lamp, Fig. 4; c. petroleum lamp, Fig. 2.

3. **Penumbra Polarizers.** a. Jellet-Cornu's model, improved by Schmidt & Haensch; b. Schönrock's model; c. Lippich's model, in two parts; d. Lippich's model, in three parts. German patent No. 82,523.

All these polarizers, a to d, are adaptable for saccharimeters with invariable penumbra; c and d are also available for saccharimeters with penumbra with measurable movement.

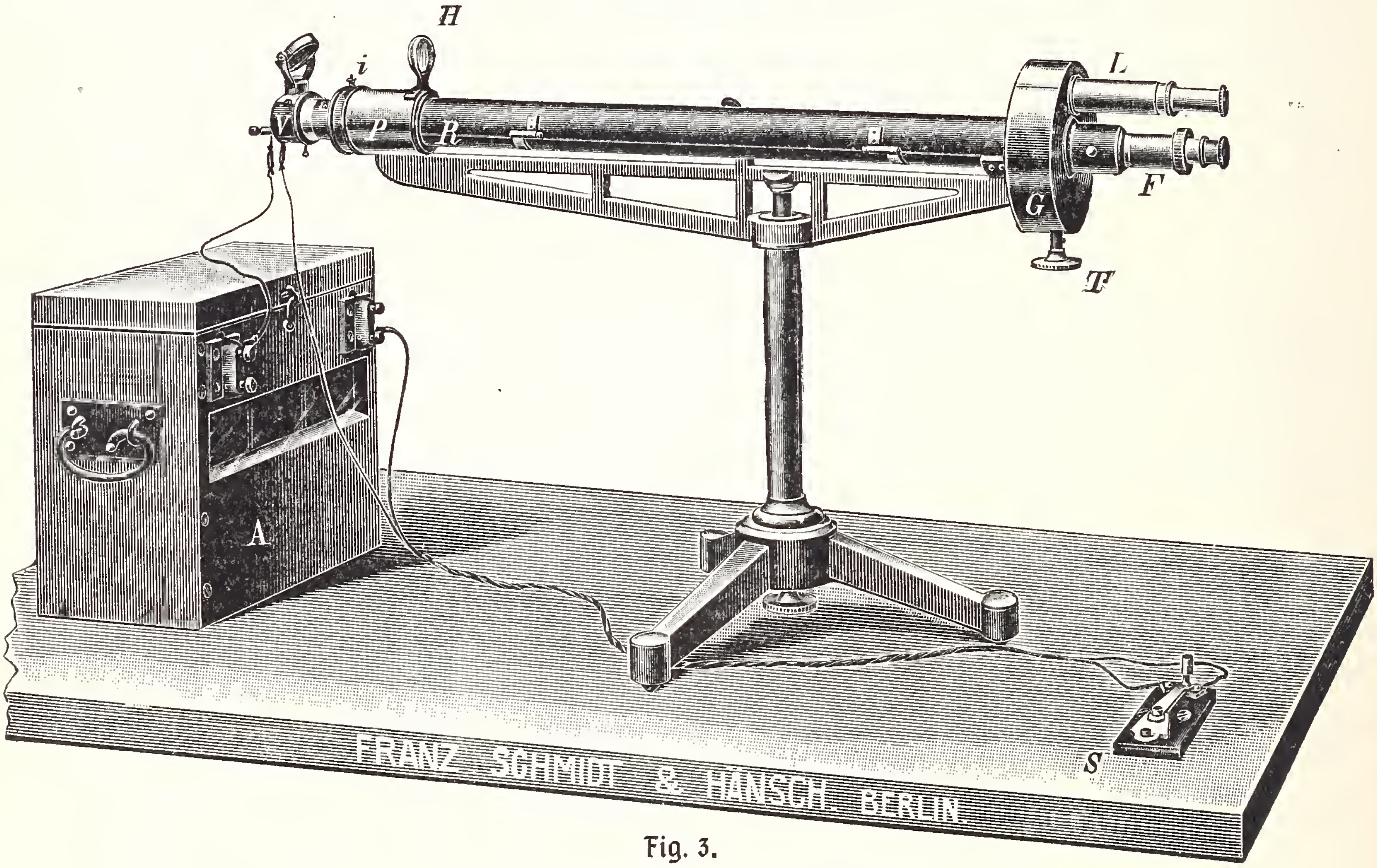


Fig. 3.
Saccharimeter with simple wedge compensator.

4. **Saccharimeter with limited measuring range.** (Fig. 2.) The quartz wedge compensation (devised by Martens,[1] and protected by patent application) consists merely of a left-handed and right-handed quartz wedge, the thick ends of which are turned towards the same side and the deflection of which is compensated by a glass wedge. Martens's wedges are cemented at the thick ends only so as to obviate straining. (Patent applied for.)

The lamp, illuminating apparatus and polarizer are selected to suit existing requirements. Fig. 2 shows a saccharimeter with petroleum lamp, diaphragm tube B, Jellet-Cornu's polarizer P. The analyzing and measuring apparatus embraces an interval of about 40° on Ventzke's scale.

a. Apparatus for the examination of urine, fitted with an observation tube 200 mm long and scale reading the proportion of grape sugar contained in the urine direct in grammes per 100 ccm;

b. Stammer's Saccharimeter for the examination of beet-root, reading from 0 to 35° on Ventzke's scale, and having a maximum tube-length of 220 mm.

c. Saccharimeter, similar to b with a maximum tube-length of 400 mm.

d. Saccharimeter for solutions of high percentages. This apparatus is adapted for examining a solution of the entire standard weight in a tube 400 mm long and furnishes direct readings of the percentage of cane sugar. The measurement extends from 80 to 100 per cent.

[1] Scientific optician of the firm.

These saccharimeters can also be supplied with a limited range and fitted with a Flatow magnifying scale (D. R. G. M. No. 98,550). The displacement of the wedge is in this case effected by the rotation of a large circle which is divided into and reads direct to $^1/_{10}$ per cent. The wedge-slide is fitted with a scale which serves for controlling the readings of the divided circle.

5. **Hand Saccharimeter,** adapted for the examination of normal solutions in a 100 mm tube, reading direct percentages, the range of the scale being from 0 to 100 per cent, and fitted with magnifying scale.

6. **Saccharimeter with Simple Wedge Compensator,** reading from 0 to 100° on Ventzke's scale. The component parts of the analyzing apparatus are enclosed in a dust-proof casing G (Fig. 3) and can easily be removed after detaching the outer ring. The instrument is fitted with Martens's wedge compensator, and the wedge-slide is moved by the milled head T. The scale and vernier are read by a simple magnifier L, and the two sections of the penumbra are viewed by the astronomical telescope F. In the figure the instrument is shown together with its illuminating apparatus V (see

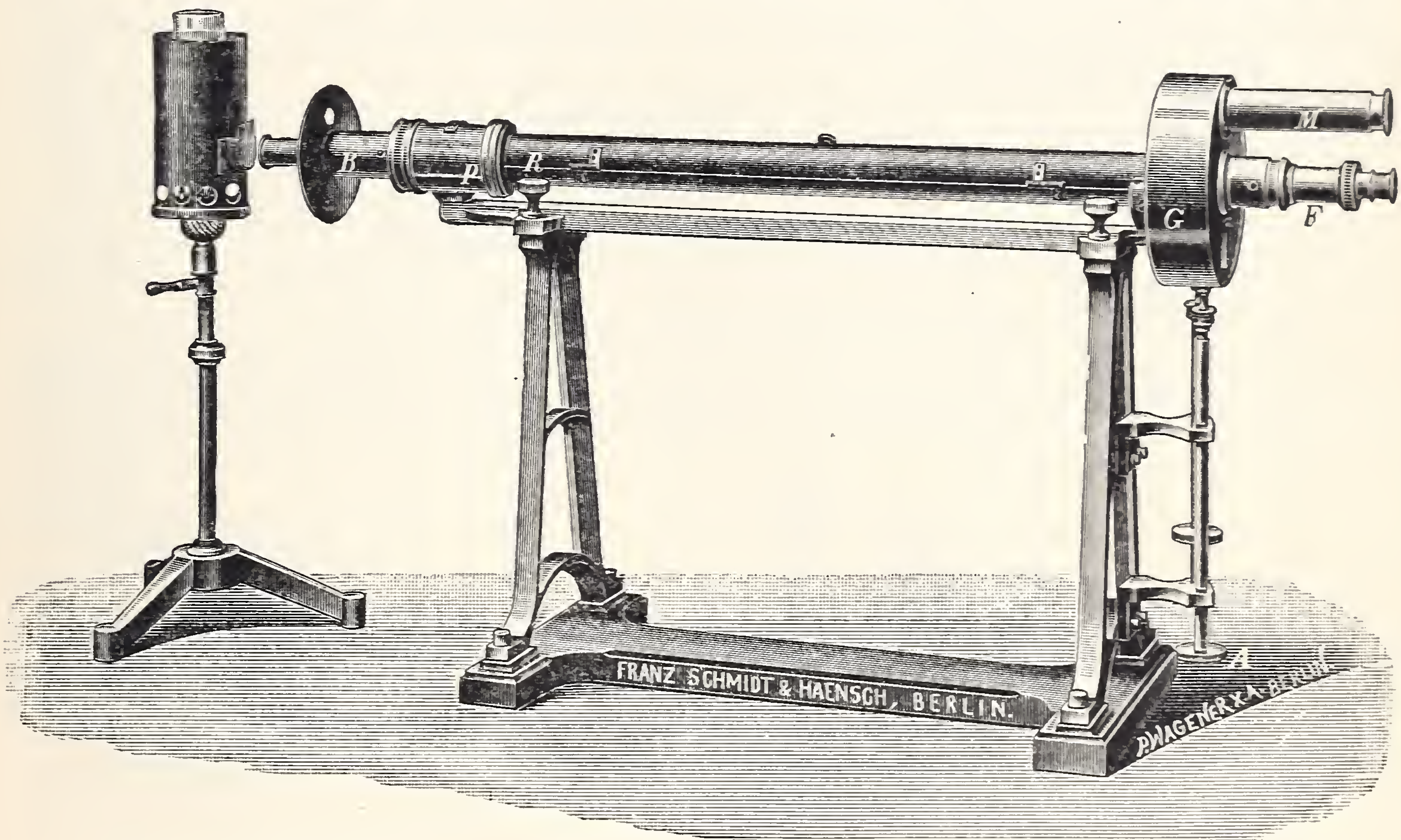


Fig. 4.
Saccharimeter with double wedge compensator.

Nos. 1 b and 2 a), which contains a small incandescent lamp supplied with current by the accumulator A through a key S. The polarizer takes generally the form of Lippich's instrument (N_1 and N_2, Fig. 1).

These instruments are made with tubes of various lengths, the greatest lengths being respectively a. 200 mm, b. 400 mm, c. 600 mm. b and c are more appropriately mounted on standards, as shown in Fig. 4, than on a column and tripod.

7. **Saccharimeter with Martens's Double Wedge Compensation.** Both scales are read by a microscope M, as shown in Fig. 4 (D. R. G. M. No. 121,323). The working wedge (having a range from 0 to +100° on Ventzke's scale) is displaced by a milled head A, the other milled head actuates the controlling wedge (having a range from 0 to −100° on Ventzke's scale). Double wedge compensation has the following advantages over single wedge compensation: 1. It is available for the polarization of fluids having a considerable laevo-rotatory power. 2. The displacement of the controlling wedge is a readier means of correcting the zero point of the working wedge than is afforded by the displacement of the vernier. 3. Any observer can, without possessing a set of standard quartz plates, verify the proper graduation of the scale and the optical purity of the working wedge.

These saccharimeters are, as a rule, fitted with Lippich's three-part polarizer. The instruments are made with maximum tube-lengths of a. 200 mm, b. 400 mm, c. 600 mm. Instruments b and c are appropriately mounted upon double standards, as shown in Fig. 4.

8. **Standard Quartz Plates,** mounted in accordance with the requirements of the Imperial Physical and Technical Institute and adapted for rotatory values of −20, +20, +35, +40, +60, +80, +90, +95, +100, +160, +200° on Ventzke's scale. In all saccharimeters made by Schmidt & Haensch a standard quartz plate gives a reading of 100° on Ventzke's scale, if at 20° C. it rotates the plane of polarization of spectroscopically pure sodium light through 34.67 circular degrees. Each plate supplied by this firm is carefully tested with respect to 1. the absence of flaws in the quartz, 2. flatness and parallelism of the surfaces, 3. coincidence of the optic and geometrical axis. The quality and rotatory power (in degrees), and also the thickness, of the plates may also be verified by the Imperial Physical and Technical Institute.

9. **Observation Tubes** are made in lengths of 25, 50, 94.7, 100, 189.4, 200, 220, 400, 600 mm. The end glasses are made either of plate glass or of finely annealed crown-glass, and either screwed into the tubes or pressed against them by Landolt's sliding sleeve. The tubes are made either of brass or glass. The following forms may be specially mentioned:—a. Wicke's tube with unilateral expansion for the extraction of air-bubbles. German patent No. 104,846; b. Pellet's tube for an uninterrupted flow; c. tubes with water circulation and thermometer for the examination of solutions of inverted sugar; d. controlling tube with variable and measurable length of the stratum under examination.

10. **Mitscherlich's Polarizing Apparatus,** together with a sodium lamp with Winter's platinum ring and two oberservation tubes 94.7 and 189.4 mm long respectively and Jellet-Cornu's polarizer. The rotation of the analyzing Nicol reads to 0.1° by a circle divided into 360°. This apparatus is primarily designed for the examinations of urine and is adjusted so as to give with a tube 189.4 mm long direct readings of the proportion of grape sugar (in grammes per 100 ccm of the fluid).

11. **Polarizing Apparatus** of an original design, with Lippich's three-part polarizer with adjustable penumbra angle. The divided circle reads to 1' or 0.01°. The apparatus is adapted for tubes, a. 200 mm, b. 400 mm, c. 600 mm long. a is mounted on a tripod and pillar, b generally and c exclusively upon double standards.

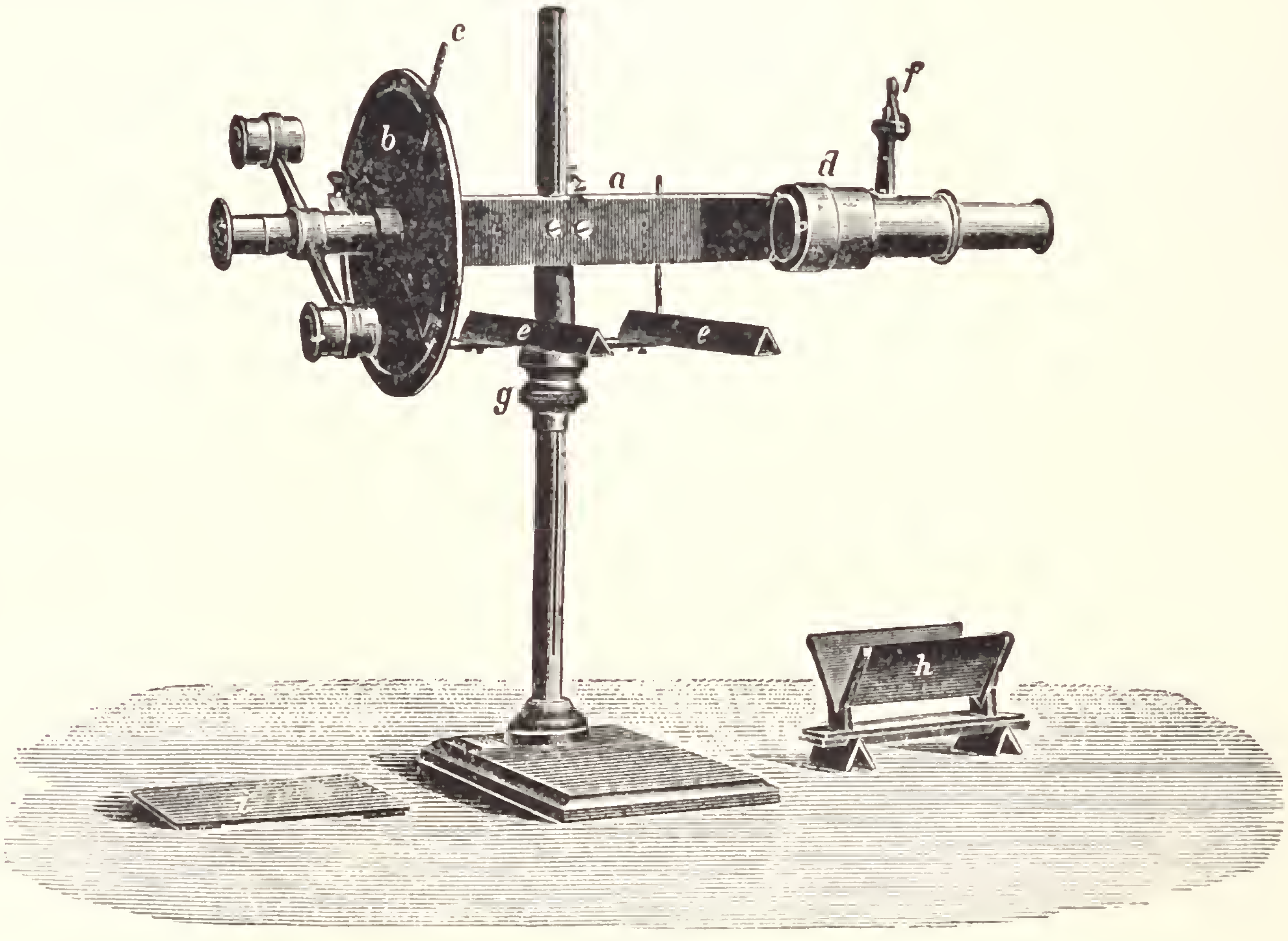


Fig. 5.
Landolt's polarizing apparatus.

12. **Landolt's Polarizing Apparatus,** Fig. 5, adapted for a great variety of investigations, such as the influence of temperature of the specific rotation, electromagnetic rotation, &c.
The rotation of the analyzing Nicol prism reads to 0.01°.

13. Large Polarizing Apparatus on double standards. The polarizer and analyzer are mounted on a large iron bench supported upon two standards. The space between the latter is entirely free and available for setting up wire coils, &c.

14. Lippich's Universal Polarizing Apparatus. Similar to No. 13, but the standards carrying the polarizer are movable on a sole-plate and can be clamped in any position.

II. Spectrum Appliances.

The Prismatic Spectroscopes made by this firm are compiled in the subjoined table.

Table of Prismatic Spectroscopes.

Description		No.	Fig.	Nature of measuring device	Available diameter of the objective[1]) mm	Dispersion C–F (656 to 486 $\mu\mu$)	Resolving power $\frac{\lambda}{d\lambda}$ [2])	Smallest separable distance between two consecutive lines $d\lambda$ in $\mu\mu$
Pocket spectroscopes (without telescope)		15a	6	—	6	5° 30′	550	1.03
		15b	—	—	-	-	-	-
		15c	7	Scale	-	-	-	-
Small Kirchhoff and Bunsen spectroscopes with	Flint prism	16a	—	Wave-length scale	15	1° 56′	3,000	0.19
		16b	—		-	-	-	-
		16c	8		-	-	-	-
	Rutherford prism	16d	—		15	3° 26′	5,300	0.11
		16e	8		-	-	-	-
Large Kirchhoff and Bunsen spectroscope with	Flint prism	17a	—	Scale and micrometer screw	24	1° 56′	4,800[3])	0.12[3])
	Rutherford prism	17b	—		24	3° 26′	8,400[3])	0.067[3])
Hoffmann's direct vision spectroscope		18	—	Micrometer screw, or micrometer and scale	15	5° 30′	8,500	0.066
Intermediate spectrometer with 2 Rutherford prisms		19	—	Divided circle reading to 0.1′, and micrometer screw	30	6° 52′	21,000[3])	0.027[3])
Large spectrometer with	3 Rutherford prisms	20a	—	Divided circle reading to 1″	42	10° 18′	44,000[3])	0.013[3])
	6 Flint-glass prisms	20b	9		42	11° 36′	50,000[3])	0.011[3])

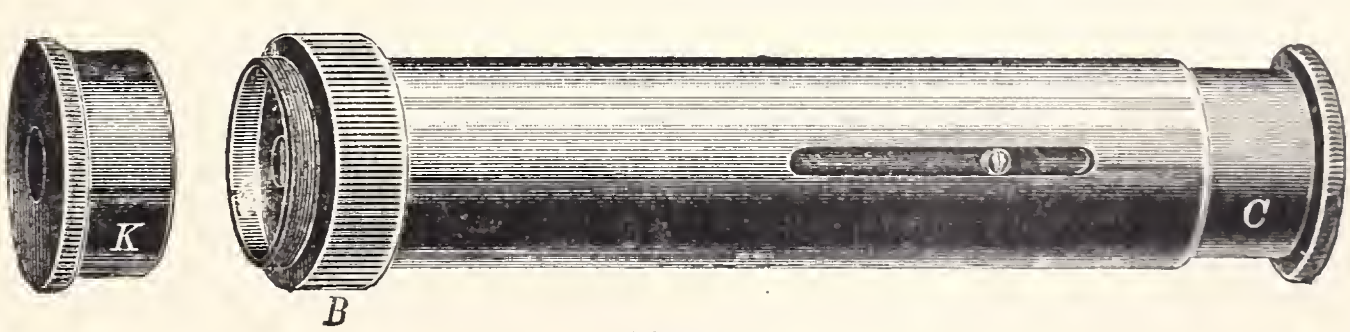


Fig. 6.
Simple pocket spectroscope.

[1] The focal length of the objectives are equal to ten times their aperture.
[2] In order to separate the D-line the resolving power should be at least = 1,000.
[3] The resolving power is doubled by doubling the passage of the light through the prism by Abbe's method of autocollimation.

15. The Pocket Spectroscopes (No. 15 a, b, c in the preceding table) consist merely of a slit, aplanatic lens and direct vision prism, and are not fitted with a telescope. The simplest of these (No. 15 a) is shown in Fig. 6; No. 15 b is fitted with a comparison prism and illuminating mirror, No. 15 c has a scale comparison prism and illuminating mirror. Fig. 7 shows the same mounted on a universal stand.

16. to 20. The Spectroscopes of the Kirchhoff and Bunsen pattern are made in two sizes. Of the smaller instruments No. 16 a is fitted with a fixed, No. 16 b with a movable telescope. No. 16 c, as shown in Fig. 8, has a telescope fitted with a rack and pinion T, a fixed protecting cap C, a wave-length scale S and illuminating mirror B. In the larger instruments (Nos. 17 a and b) the telescope can be turned about a long axis either by hand or by a micrometer.

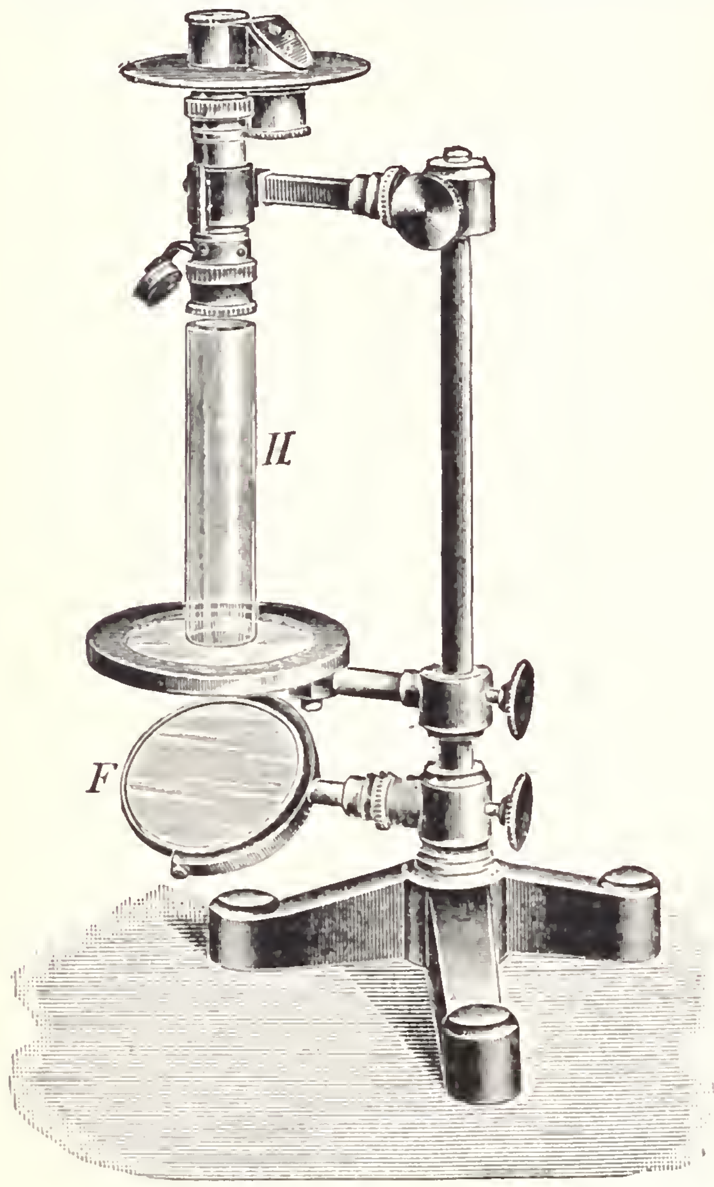


Fig. 7.
Pocket spectroscope with scale and universal stand.

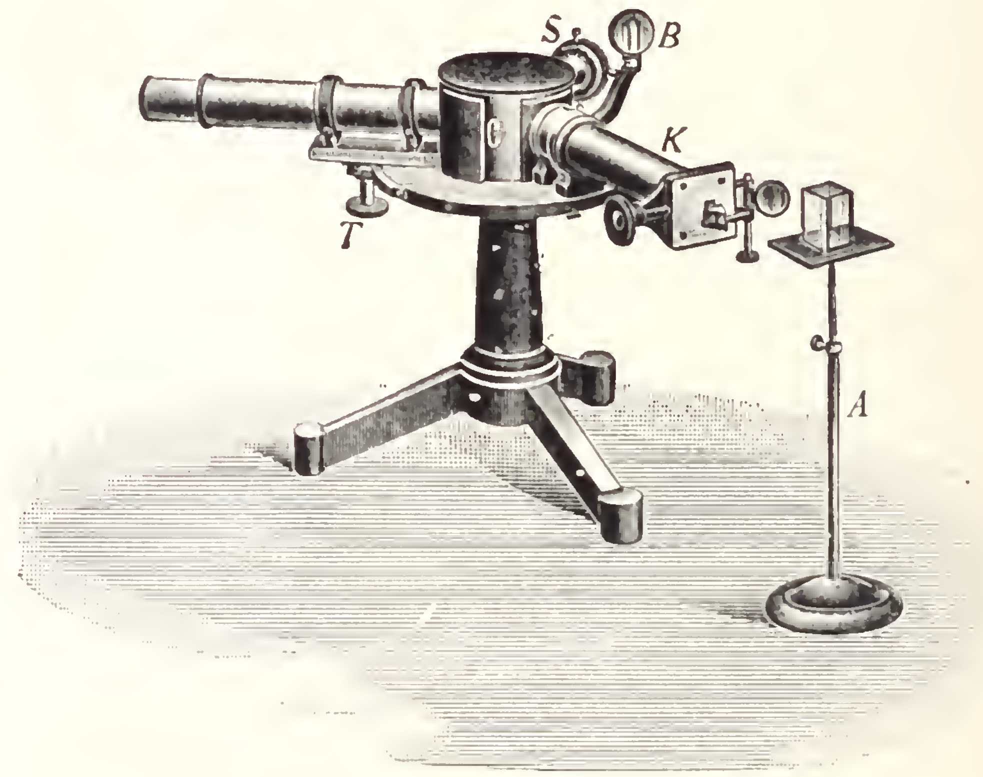


Fig. 8.
Kirchhoff and Bunsen's spectroscope.

The Spectroscopes of exceptionally high resolving power (Nos. 19 and 20 a and b) are modifications of the spectrometers Nos. 21 b and 21 c fitted with specially arranged prism stages.

21. New Precision Spectrometers, with fixed graduated circle; rotating telescope fitted with verniers or microscopes, stage for raising and lowering and made to revolve by means of 6 prongs, either with or without scale. The upper plate of the stage can be adjusted and the slits and eyepieces interchanged at pleasure.

- a) Small model, with divided circle reading to 1' by a microscope having its eyepieces situated immediately below the telescope eyepiece.
- b) Intermediate model.
- c) Large model, Fig. 9. In both models (b and c) the readings are taken, within 0.1' and 1" respectively, by reading microscopes MM having their eyepieces below the telescope.

The telescope carrier x is supported by a roller r running upon a circular rail attached to the tripod, so as to provide for the adaptation, in the place of the telescopes, of measuring appliances, irrespective of their weight, e. g. photographic cameras, Rubens's concave mirror-arm, collimator with luminant, &c., without risk of injuring the instrument. The telescope F and collimator K can be turned about two axes aa and fixed by means of the clamps at cc. The instruments are equipped with two stages of various sizes. If desired, the spectrometers may be fitted with automatically moving prisms.

22. New Universal Spectrometer:—a. Small, b. intermediate, c. large model. These instruments differ from the precision spectrometers of the same size only in that their central axis rotates together with the divided circle and stage, the rotation being effected by a pronged wheel situated below the instrument.

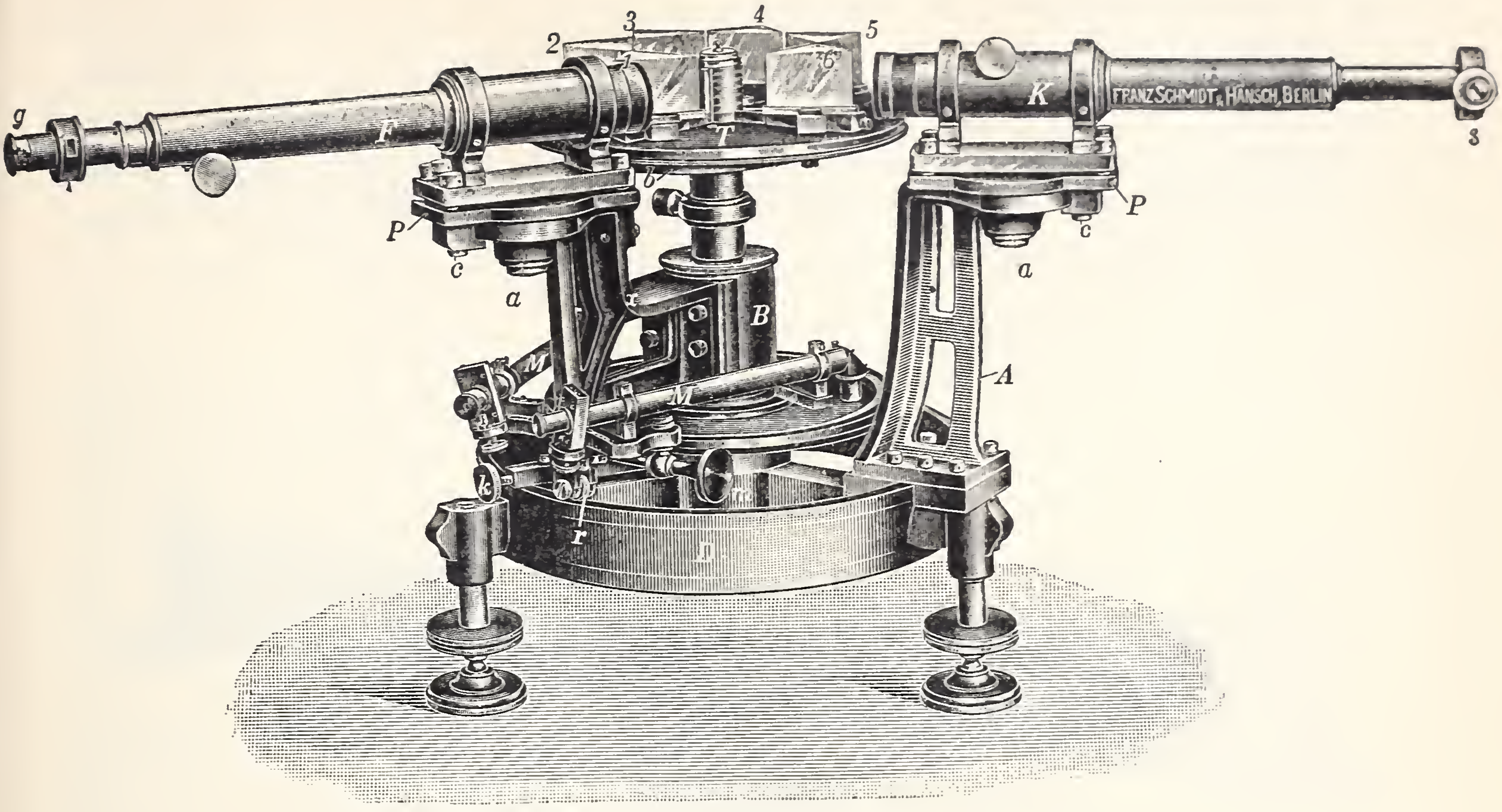


Fig. 9.

Large spectrometer with 6 automatically moving flint prisms.

Any of the eyepieces and slits made by this firm fit into the draw-tubes of all their telescopes.

23. Eyepieces:—
   a) Simple Huyghenian eyepieces fitted with cross-lines having a focus of 40 mm. Simple Ramsden eyepieces having foci of 28, 19, 11 and 7 mm. Steinheil eyepieces having foci of 20, 9 and 7 mm.
   b) Gauss's and Abbe-Lamont's eyepieces with illuminated cross-lines.
   c) Glass or screw-micrometer eyepieces.
   d) Eyepieces for special purposes fitted with Wellmann's luminous line, Glan's adjustable slit or with spectroscope, Soret's fluorescent plate, improved by Martens.

24. Lummer and Kurlbaum's Linear and Surface Bolometer.

25. Rubens's Linear Thermo-electric Pile.

26. Slits:—a. Eyepiece slit with attachable magnifier; b. simple slit, Fig. 8, with divided drum, comparison prism and illuminating mirror for the latter; c. Wadsworth's bilateral slit with differential screw; d. bilateral double slit; e. Abbe's autocollimation slit.

27. Prisms:—a. For teaching purposes; b. rectangular Fresnel and Porro reflecting prisms; c. Lummer and Brodhun's, Brace's and twin prisms for photometric purposes; d. absorbing troughs and bottles; e. Steinheil's and Hallwachs's differential fluid prism; f. dispersion prisms (equilateral flint prisms, Rutherford prisms, &c.).

III. Measuring Instruments.

28. Scales:—
   a) White paper scale with electrical appliances.
   b) Martens's laterally illuminated glass scale. Fig. 10.
   c) Milk-glass scale.
   d) Opal-glass scale.
   e) Large demonstration scale for lecture theatres.

29. Reading Mirrors:—
a) Plano-parallel mirrors,
b) Reflecting lenses (with plane and silvered convex surface).

30. Reading Telescopes:—
a) Small model, mounted so as to rotate about a vertical and horizontal axis to any desired extent.
b) Large model, as shown in Fig. 10 together with a laterally illuminated scale.

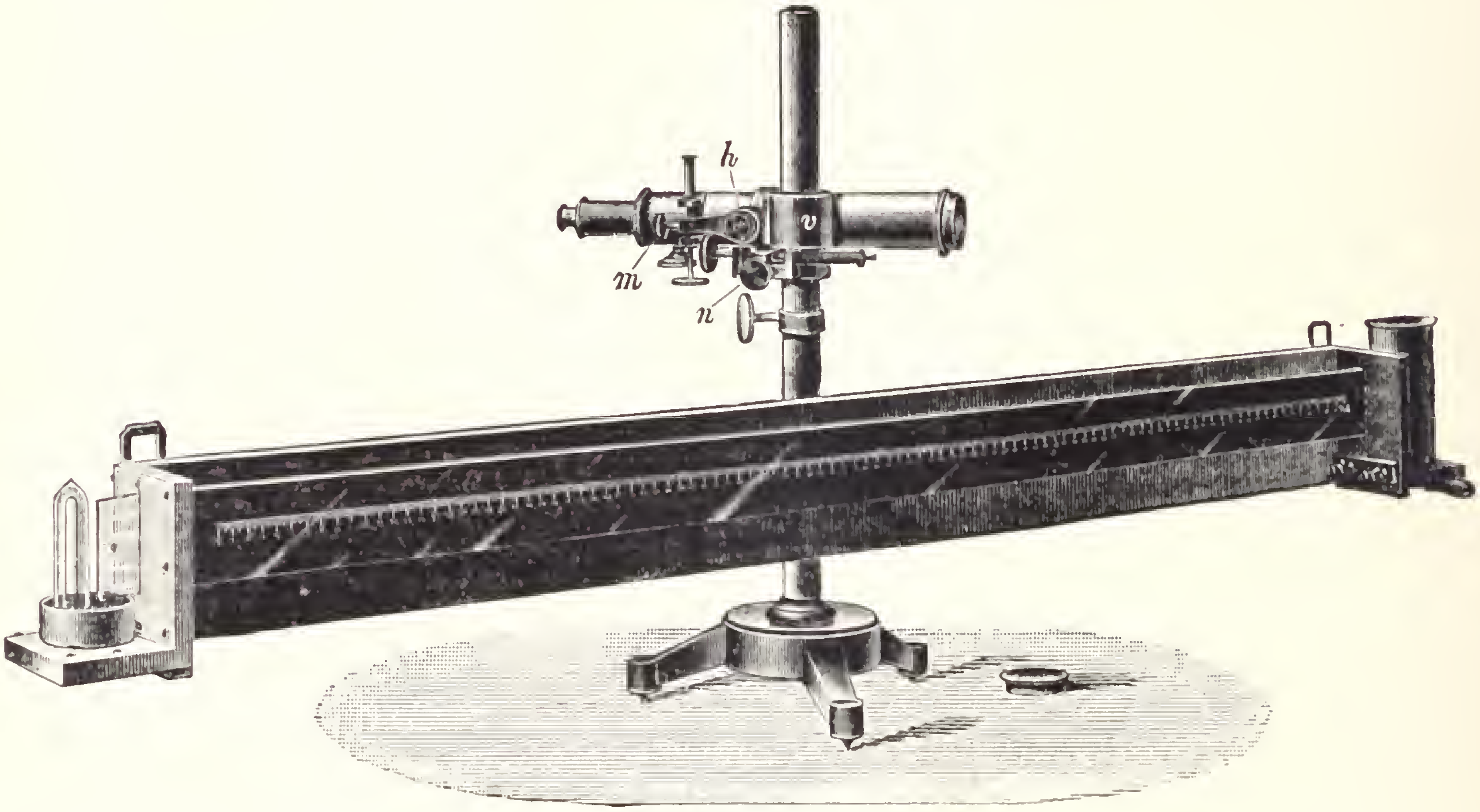


Fig. 10.
Large reading telescope with Martens's laterally illuminated scale.

31. Scale Lanterns:—
a) With incandescent lamp having a U-shaped filament adjusted for 110 or 55 volts and 0.5 ampère.
b) With incandescent lamp adjusted for 8 volts and 6 ampères, also with lens for throwing an image of the carbon filament on the scale for demonstrating the movements of a galvanometer mirror in a large lecture theatre.

32. Tornoe's Refractometer with Hallwachs's differential prism. n_1 and n_2 being respectively the refractive indices of medium 1 and solution 2 (Fig. 11). The unknown refractive index is found by the following equation

$$n_2^2 - n_1^2 = \sin^2 \alpha.$$

This refractometer has been practically employed in Tornoe's optical hydrometric method for the analysis of beer.

33. Martens's Compensating Refractometer with Hallwachs's differential prism. White lamp-light or day-light may be used for the illumination. The angle α is measured by rotating two Straubel prisms with respect to each other.

34. Von Helmholtz's Ophthalmometer.

35. Thorner's New Ophthalmoscope, mounted on an adjustable stand with lamp. This apparatus has over other instruments for retinal observation the advantage that 1. a much larger area of the retina can be viewed at one operation, and 2. the light reflected by the cornea is, by an ingenious arrangement, prevented from reaching the observer's eye.

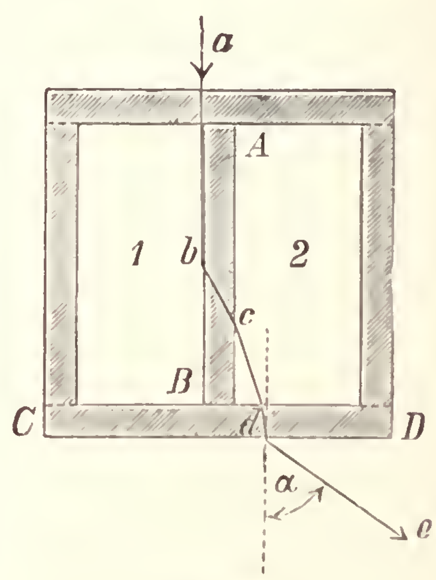


Fig. 11.
Hallwachs's differential prism.

7. Dr. Steeg & Reuter, Homburg v. d. H. (Bad Homburg).

Optical Institute. Established 1855.

Gold Medal: Naples 1870. Silver Medal: Moscow 1872. Progress Medal: Vienna 1873. Diplomas: Graz 1880 and Frankfort-on-the-Main 1881. Gold Medals: Vienna 1883, Antwerp 1885. Diploma and Gold Medal: Brussels 1888. Diploma and Gold Medal: Chicago 1893.

(See also Section Vg.)

1. **Nörremberg's Polariscope,** for convergent light, with very large field, revolving divided stage and goniometer for measuring the angles of axes.

2. **Tourmaline Forcepses** with and without lenses.

3. **A Set of 16 differently formed chilled glasses.**

4. **Preparations of Calc-spar.** Polarizing prisms of various kinds after Nicol, Foucault, Glan, Thompson, Hartnack, Ahrens, Glazebrook, Jellett-Cornu, Lippich. Amongst these will be found a Nicol prism having an aperture of 40 mm and a Foucault prism of 55 mm aperture. Various double refracting prisms. Plates for measuring instruments. Three large rhombohedrons having different faces. A polished piece of spar with large movable spirit-level.

5. **Quartz Preparations:** Large prisms and lenses of absolutely pure material, among these being a biconvex lens having a diameter of 120 mm. Cornu prism. Triple Fresnel prism. For mineralogical investigations: A large assortment of wedges of different grades. Soleil's double plate, Bertrand's quadruple plate. Polariscopes. For saccharimetry: Soleil's wedge compensators, and standard plates.

6. **Selenite and Mica Preparations:** Retardation films, double plates, wedges of different grades, E. v. Fedorow's mica wedges, concave plates, various selenite pictures, mica combinations after Reusch and Nörremberg.

7. **Accessories for Spectrometers:** Solid and hollow prisms of various qualities and sizes. Triple, quadruple and septuple Amici or Janssen prisms. Rutherford prisms. Wernicke's fluid prisms for direct vision and deflected rays.

8. **Preparations for Experiments on Radiation of Heat.** Rock-salt lenses, prisms and disks of pure material.

8. C. A. Steinheil Söhne, Munich, 7 Theresienhöhe.

Optical and Astronomical Works. Established 1855.

Proprietor: Dr. Rudolf Steinheil.

(See also Sections II, Ve and Vf.)

I. Spectrometers.

1. **Normal Grating Spectrum Apparatus** (Fig. 1). Improved form (see Zeitschrift für Instrumentenk. 1898, p. 280).

This apparatus is adapted both for the optical observation of the spectrum formed by a plane Rowland grating of the 1st, 2nd or 3rd order with the aid of a reading telescope and for photographing the diffraction spectra, in which latter case the telescope is removed and replaced by a photographic camera fitted with a lens, ground screen and dark-slides for 6×9 cm plates.

The deviation of the rays is measured by means of a quadrant divided on silver into intervals of 10' and reading by a vernier and magnifier to 10". The observed deviation is reduced to wave-lengths with the aid of a formula.

A scale can be seen or photographed together with the spectrum. (Three successive spectra can be photographed on each plate.)

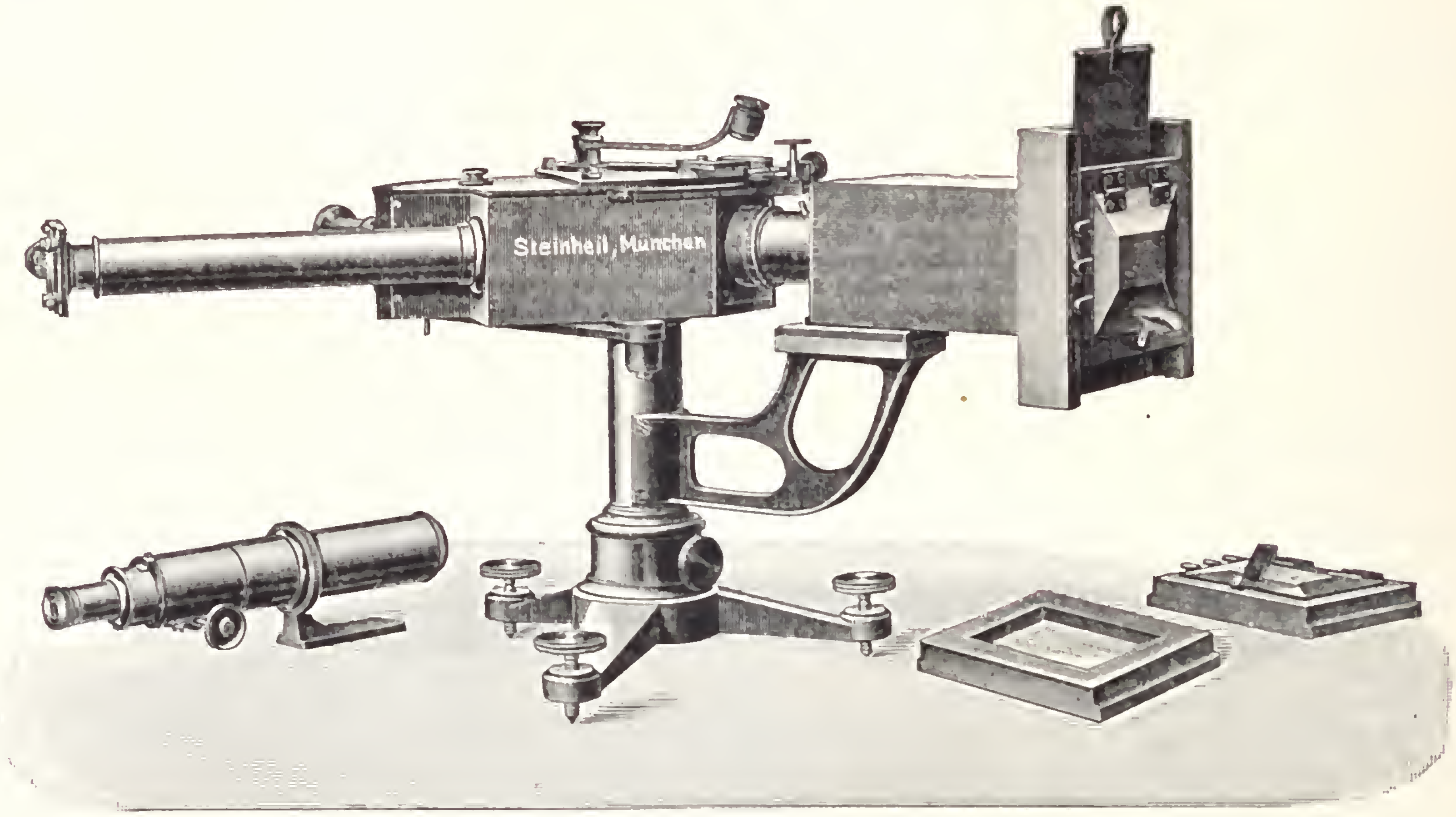


Fig. 1.

2. **Simple Spectrograph with Stand** (Fig. 2), primarily adapted for testing orthochromatic plates, &c.

The spectrum is formed by a quintuple direct vision prism and photographed with the aid of a camera. The camera and spectroscope are clamped to a simple rotating brass column mounted upon a tripod.

The width of the slit is shown by a divided drum. A rack and pinion movement facilitates the adjustment. The apparatus is fitted with a detachable cylindrical lens and is adapted for 13×18 cm plates. Five successive photographs can be taken on one plate.

II. Spectrometer Accessories (Prisms).

a. **Crown or Flint Glass Prisms** of 90° with two round polished faces.

b. **Crown Glass Reflecting Prisms,** 90°, with three polished surfaces, those including the right angle being round.

c. **Crown Glass Reflecting Prisms,** 90°, rectangular faces with sharp edges.

d. **Triple Rutherford Prism,** being a heavy flint prism cemented between two crown glass prisms.

e. **Small Fluid Prism** (Fig. 3), having an internal diameter of 20 mm. The openings are closed, without the aid of any cementing medium, by optically plane and parallel glass disks, sufficient adhesion being obtained by perfect contact.

III. Optical Measuring Instruments.

Telescopes for reading scales directly or by reflection at a mirror.

a. **Ordinary Reading Telescope** (Fig. 4), with double objective and simple astronomical eyepiece A D, on simple stand fitted with scale carrier and scale.

The telescope can be rotated through 30° on its horizontal bearings. The vertical stem is fitted with a clamp and micrometer adjustment. The low power eyepiece is provided with cross wires.

b. Reading Telescope fitted with triple objective and micrometer eyepiece AF, so as to give a bright image, with new micrometer stand.
The telescope can be swung 60° up and down. The horizontal and vertical movements are actuated by micrometer movements.
The scale can be attached to the stand both in a horizontal and vertical position.

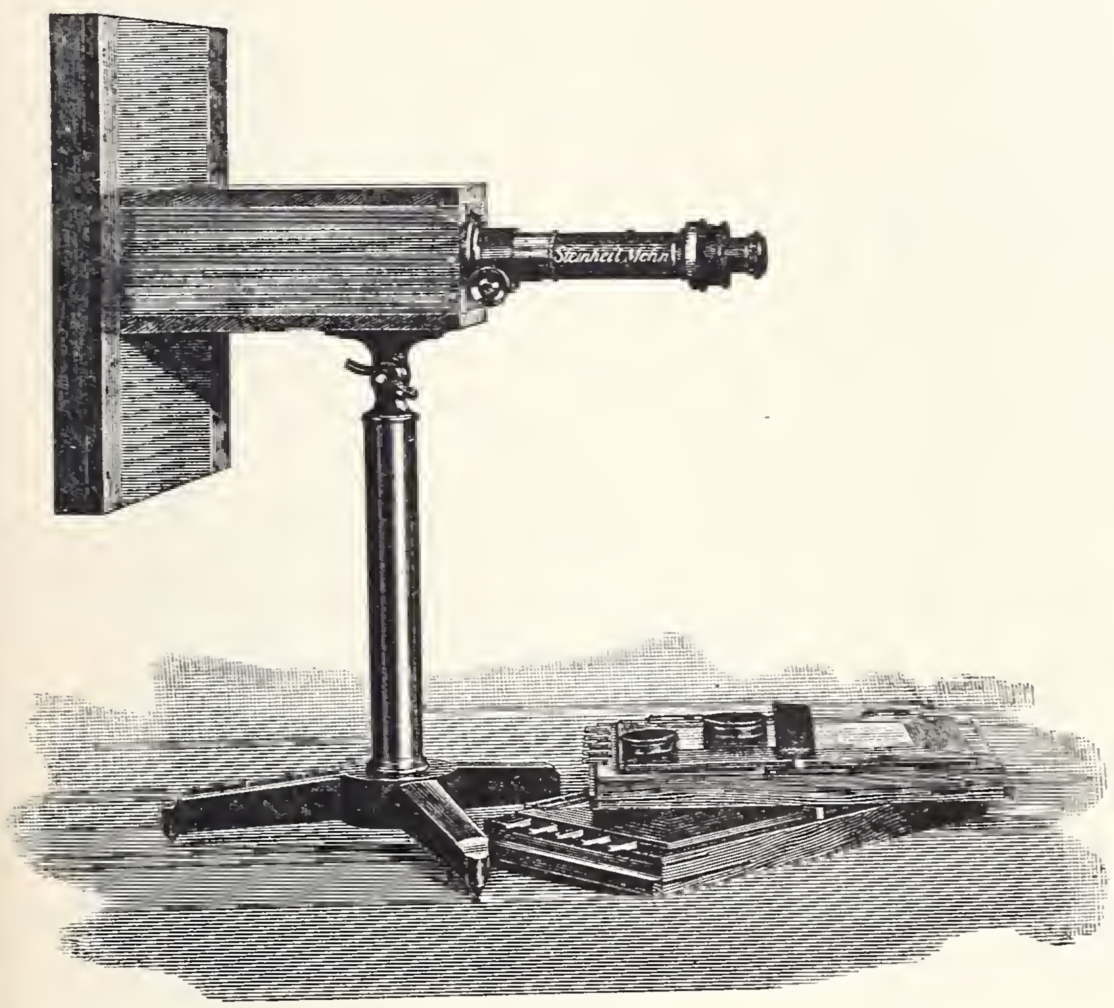


Fig. 2.

Fig. 3.

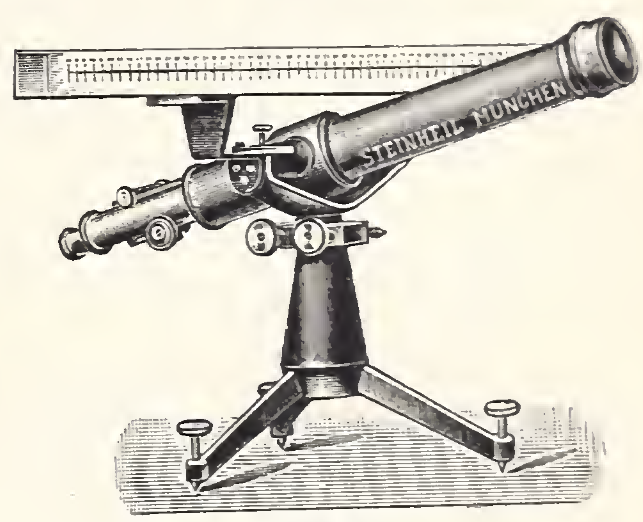


Fig. 4.

IV. Optical Auxiliaries for various purposes.

Aplanatic Magnifiers, triple cemented, perfectly achromatic, yielding faultlessly sharp images without distortion up to the edge.

Exhibits:—Aplanatic magnifier in polished brass mount. Aplanatic magnifier in brass or aluminium folding mount, single and double lenses. Set of aplanatic magnifiers with holder, in case. Plano-parallel and plane test glasses.

9. Max Wolz, Bonn-on-the-Rhine.

Scientific Instrument Maker.

(See also Section IIIb.)

Prof. H. Kayser's Apparatus for Measuring Spectrograms. This apparatus is constructed for the purpose of measuring the distances between the lines visible on the photographs of spectra. It is based upon the principle of the dividing engine:—A fine screw moves a slide which

carries the plate and thereby places each successive line under the cross-lines of a laterally mounted microscope. In instruments of this kind, as usually constructed, it is necessary each time to read the position of the micrometer head with respect to a fixed index or vernier. This process of alternate adjustment and reading is not only very fatiguing but conductive to inaccuracy. The chief novelty of this instrument consists in the fact that each adjustment, instead of being read on the micrometer head, is registered by a printing recorder. For this purpose the micrometer head is provided with lines and figures extending from 1 to 100. Another similar head rides loosely on the same spindle side by side with the fixed head and is connected with the latter by a tooth gearing in such a manner as to travel one division of the scale while the fixed head describes one complete revolution. A pointer is situated below and between these two disks. While turning round, these disks run on two felt rollers saturated with colour for giving the required impressions. A tape passes below both disks which is pressed against the latter by the depression of a button situated on the left side of the instrument, whereby an impression of the lines, numbers and the index is produced on the tape. The pressure on the button displaces at the same time the tape automatically through a certain distance. While measuring, the observer needs therefore not remove his eyes from the microscope, it being sufficient to press the button after each observation. The readings are subsequently furnished by the tape marks. The loose disk indicates the entire revolutions, hundredths are indicated by the movement of the fixed disk, and tenths divisions can easily be estimated from the distance of the index from the adjacent division lines. The screw has a pitch of about 0.33 mm. It is very carefully cut so as to exclude the necessity of providing special screw corrections. The distances separating two lines on the spectrum can therefore be measured directly and accurately within 0.00033 mm.—The track of the slide embraces about 15 cm. For the convenience of the observer the microscope is mounted in a slanting position, and the plate-carrier is correspondingly inclined. While measuring it is often desirable to append to the positions of the various lines notes respecting their intensity, definition, &c.; for which purpose the apparatus is provided with four other buttons so as to imprint 1, 2, 3 or 4 points upon the tape next to the registered measurement. By variously combining these four points it will be seen that fifteen conventional notations are available.

This instrument is the property of Mr. Hauswald, of Magdeburg-Neustadt.

10. Carl Zeiss, Optical Works, Jena.

(See also Sections II, Vc, Vd, Ve and Vf.)

Optical Measuring Instruments.

A separate department has been established since 1892 for the construction of optical measuring instruments. This department is under the supervision of Dr. C. Pulfrich. The instruments made in this section—spectrometers and refractometers, spectroscopes, goniometers and reading microscopes, interferential appliances, telemeters, &c.—are mainly designed for use in physical, chemical and mineralogical laboratories and are available for many scientific and technical uses. The majority of these instruments are original in conception and design and have emanated from the firm's own requirements. They have been constructed successively by various members of the scientific staff either for the immediate needs of the workshops or for subsidiary experimental investigations. All of these instruments have therefore been subjected to practical tests, often for years, in the original workshops, and the majority of them have therefore through continued improvement reached their final stage.

The following instruments are exhibited:

Abbe's Spectrometer, a large model for spectrometric determinations and a smaller instrument for teaching and practicing in college laboratories, including auxiliary and accessory appliances, prisms, hollow prisms, heating apparatus, &c.

Two New Refractometers, both based upon the method of prismatic deviation. One, having a variable refracting angle, is particularly adapted for the examination of highly refracting fluids. The other is a differential refractometer, constructed for determining the difference of refraction of two fluids.

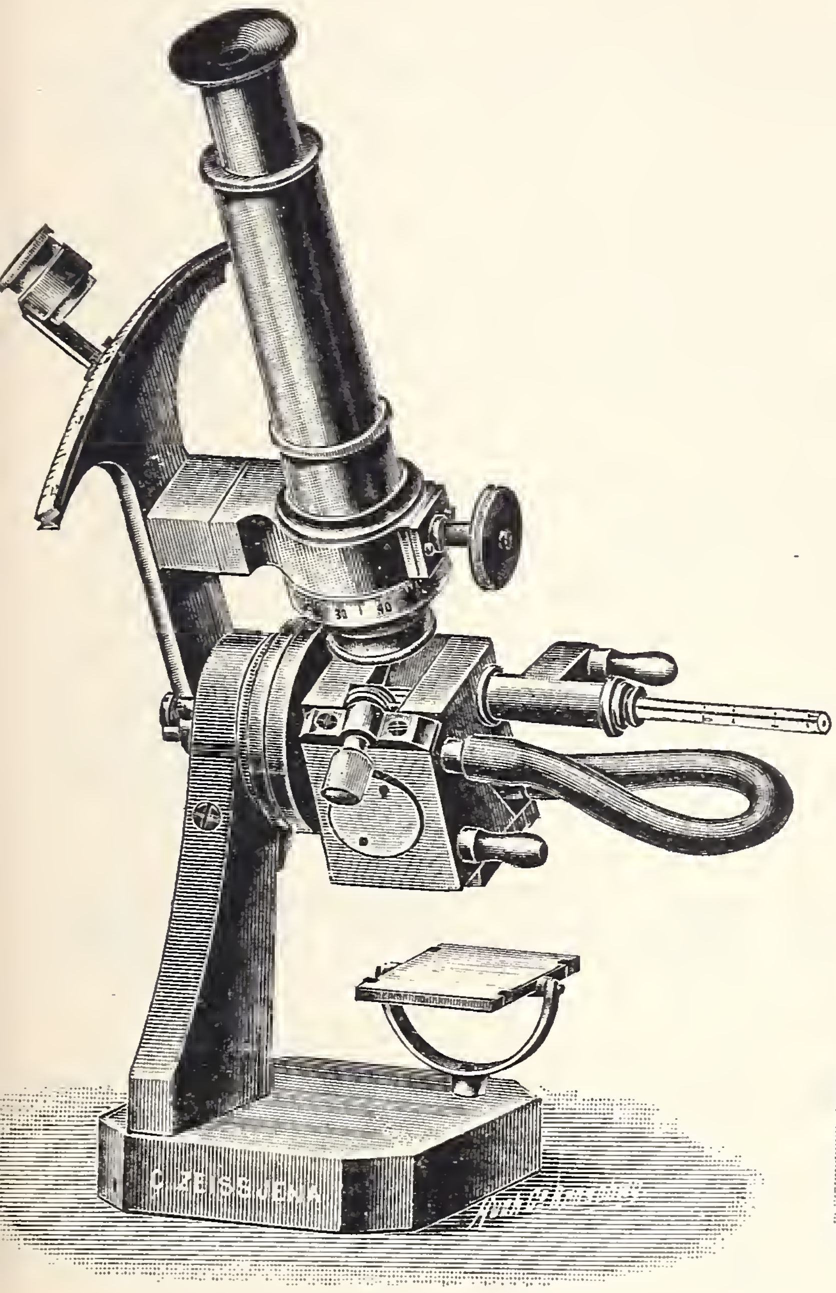


Fig. 1.

Abbe's refractometer with heating apparatus.

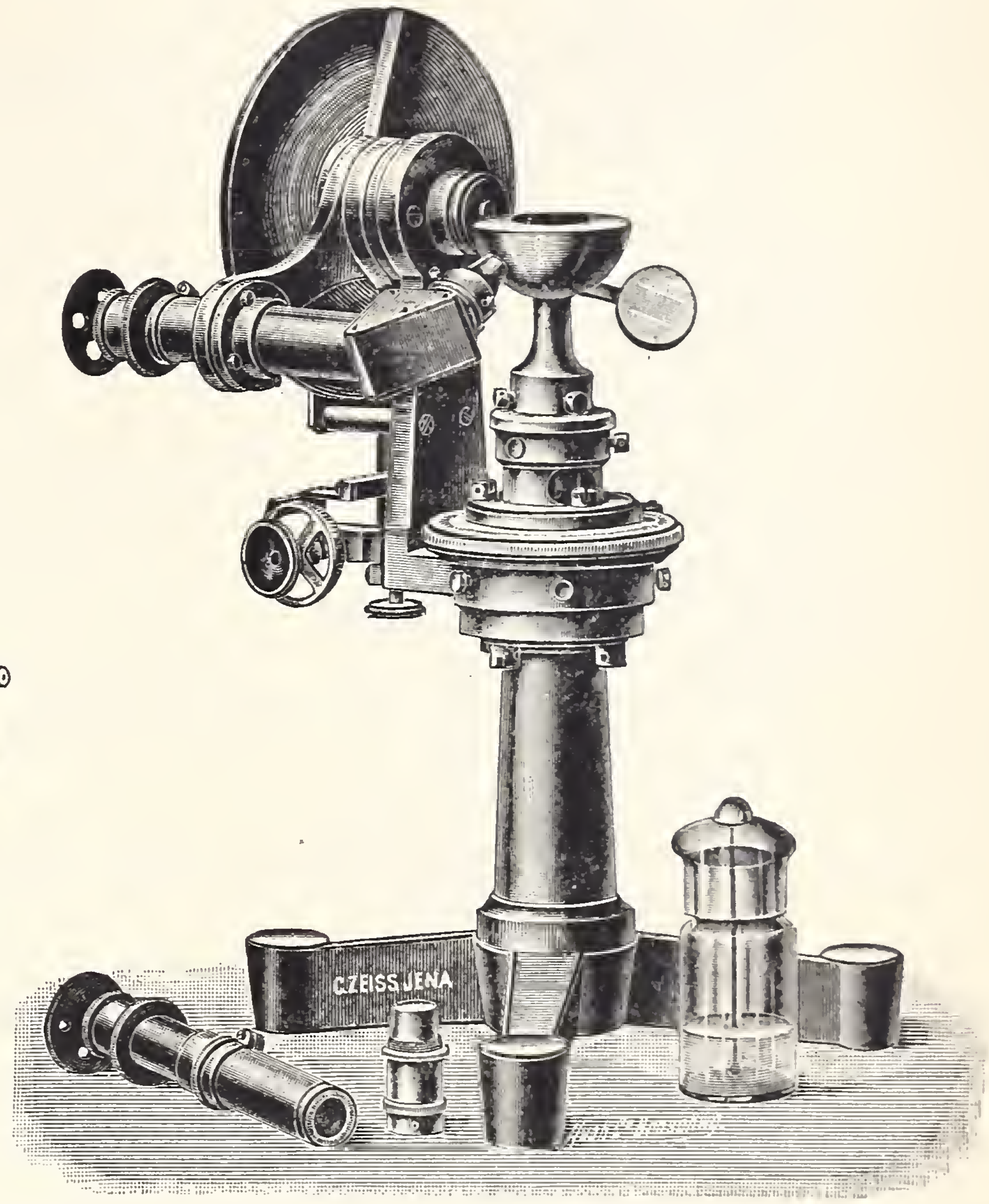


Fig. 2.

Crystal refractometer (new model).

Various refractometers based upon the observation of the critical angle of total reflection, e. g.:

Pulfrich's Refractometer (new model).

Refractometer for Colleges.

Abbe's Refractometer. Two models, one of which is fitted with prism adapted for being heated (Fig. 1).

Refractometer for Special Technical Purposes (butter, milk-fat and lard refractometers).

Crystal Refractometer (new model), eminently suited for the examination of small and defective surfaces (Fig. 2).

Laboratory Comparison Spectroscope with wave-length scale (Fig. 3).

New Fluid Prism of high dispersion.

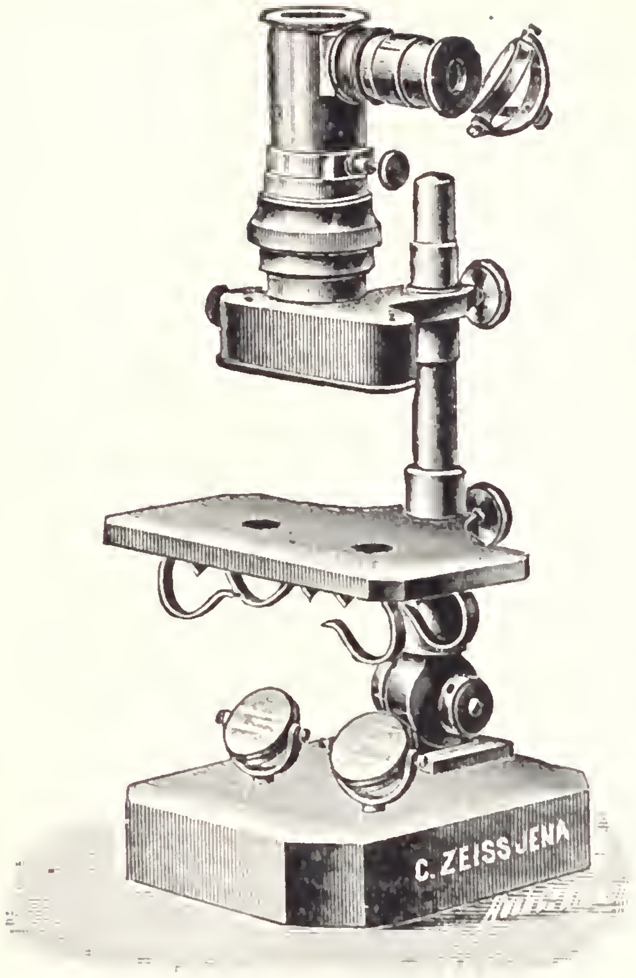


Fig. 3.
Laboratory comparison spectroscope.

New Crystal Goniometer with various improvements in the collimator, by which the path of the rays is rendered completely adjustable from the luminant to the eye of the observer. A special feature of this instrument is its adaptability for observing diffuse reflection as a means of examining small and uneven surfaces.

Various Appliances for Longitudinal Measurement (pachymeter, two forms of comparators, a spherometer and a focometer).

Abbe-Fizeau's Dilatometer.

Pulfrich's New Interferential Apparatus and stage.

L. Mach's Quadruple Plate Interferential Refractometer.

Interferential Refractometer, constructed on Jamin's principle.

New Stereoscopic Telemeter.

Descriptions of these various instruments and price-lists may be had free on application. The majority of these have been published in French, English and German.

C. Microscopes and their Auxiliaries.

1. Gustav Halle, Rixdorf near Berlin, 53 Hermannstr.

Maker of Scientific and Technical Instruments of Precision.

(See also Sections V b, V g and X.)

1. **Hand-microscope for demonstrating** the anatomy and physiology of plants, made almost entirely of aluminium and weighing only 370 g, focussing by rack and pinion, provided with two stage diaphragms.

2. **Entomological Stand-microscope,** with adjustable tube-length and rack and pinion adjustment for working-distances of 30 mm to 90 mm; adapted for opaque objects; very light and adapted for use as a hand-microscope. Stage with Cardanian joint and two objectives.

2. E. Hartnack, Potsdam, 39 Waisenstr.

Optical Works.

This firm was formerly established in Paris.

1. **The Microscopes** exhibited are in general design and construction of the form originated by this firm some 50 years ago, but the movements, especially the coarse and fine adjustments,

have been so considerably improved as to work with an extraordinary degree of smoothness, uniformity and precision. By improved methods of divided labour the stands are now produced at a considerably diminished cost.

Particular mention may be made of the cylinder iris-diaphragm and the swing-out condenser, which are both adaptable to the intermediate as well as to the large stands and greatly facilitate changes in the modes of illumination.

Of the stands, Series V is intended for the finest work. The stands of Series IV are nearly equivalent to these and adapted for clinical work and medical research (Stand IVB is shown in the annexed illustration). Stands III and II are designed for laboratory work.

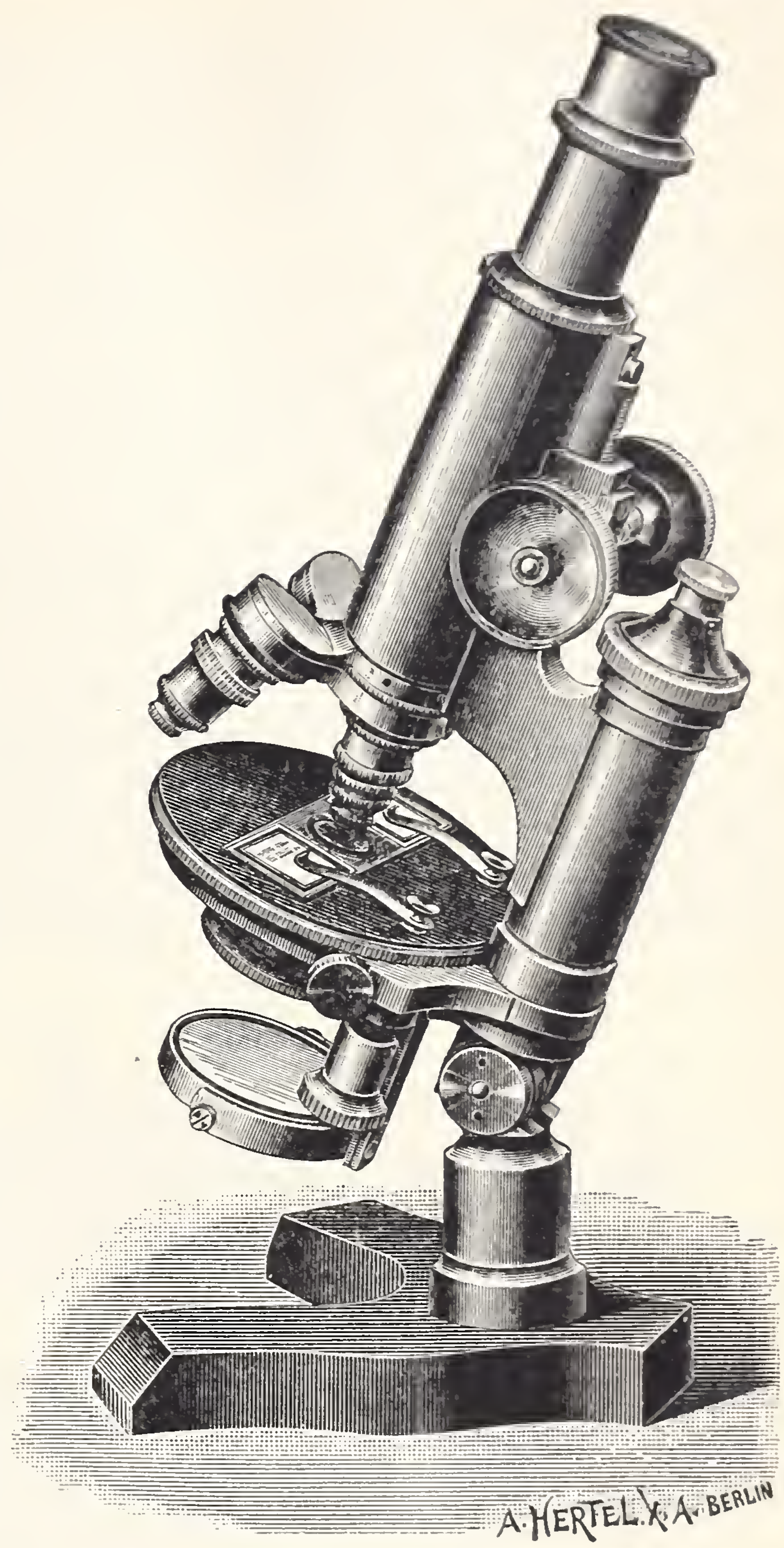
The trichinoscope has an unusually wide stage.

2. **The Binocular Microscope** suffices for magnifications not exceeding forty diameters. The instrument has an adjustable inter-pupillary distance and yields orthomorphic and stereoscopically correct images.

3. **His's Embryograph** serves for drawing sections not exceeding 32 mm in diameter. The later form of this instrument is considerably more rigid than the older model.

4. **The Objectives** have been considerably improved with the aid of Jena glasses, and their working distances have been increased. The front lenses are no more cemented but consist of solid lenses. The objectives are consequently much less liable to be injured.

5. **Various Microscope Accessories**, such as achromatic magnifiers with perfectly flat field, magnifying up to 25 diameters, in various mounts, a new lens with handle and protectors. (By turning the handle 90° the protectors are moved aside and the lens is ready for use.)



3. Otto Himmler, Berlin S. 42, 9 Brandenburgstr.

Optical and Mechanical Works.

Speciality: Microscope Objectives.

Established 1877.

A. **Microscopes** for scientific and technical purposes (for bacteriology, &c.).

B. **Microscope Objectives and Eyepieces.** Semi-apochromatic objectives, compensating eyepieces, projection lenses.

1. New demonstrating microscope, as suggested by Dr. R. Kolkwitz.
2. Travelling microscope.
3. Microscope for watching the growth of plants.

4. Mechanical object-stages.
5. Photo-micrographic and projection apparatus.
6. Polarizing appliances.
7. Dissecting microscopes and dissecting lenses.
8. Microscope accessories.

Note. The above instruments are fully described in Catalogue No. 11 (1899, German, French and English), which may be had free on application.

4. R. Jung, Heidelberg, 12 Landhausstr.

(See also Section VII.)

1. **Microtome.** N. H. I. New Heidelberg model for large brain-sections not exceeding 210 mm in diameter. Vertical movement 100 mm. Fitted with trough for cutting under alcohol. The parts serving for the orientation of the objects and other movable parts of the object-holder do not come in contact with the alcohol. The knife block is moved mechanically with the aid of a crank-wheel. The knife is simply and securely clamped in its best position. The object is roughly adjusted by means of a crank. The microtome is fitted with simple and convenient means for adjusting the thickness of the sections.

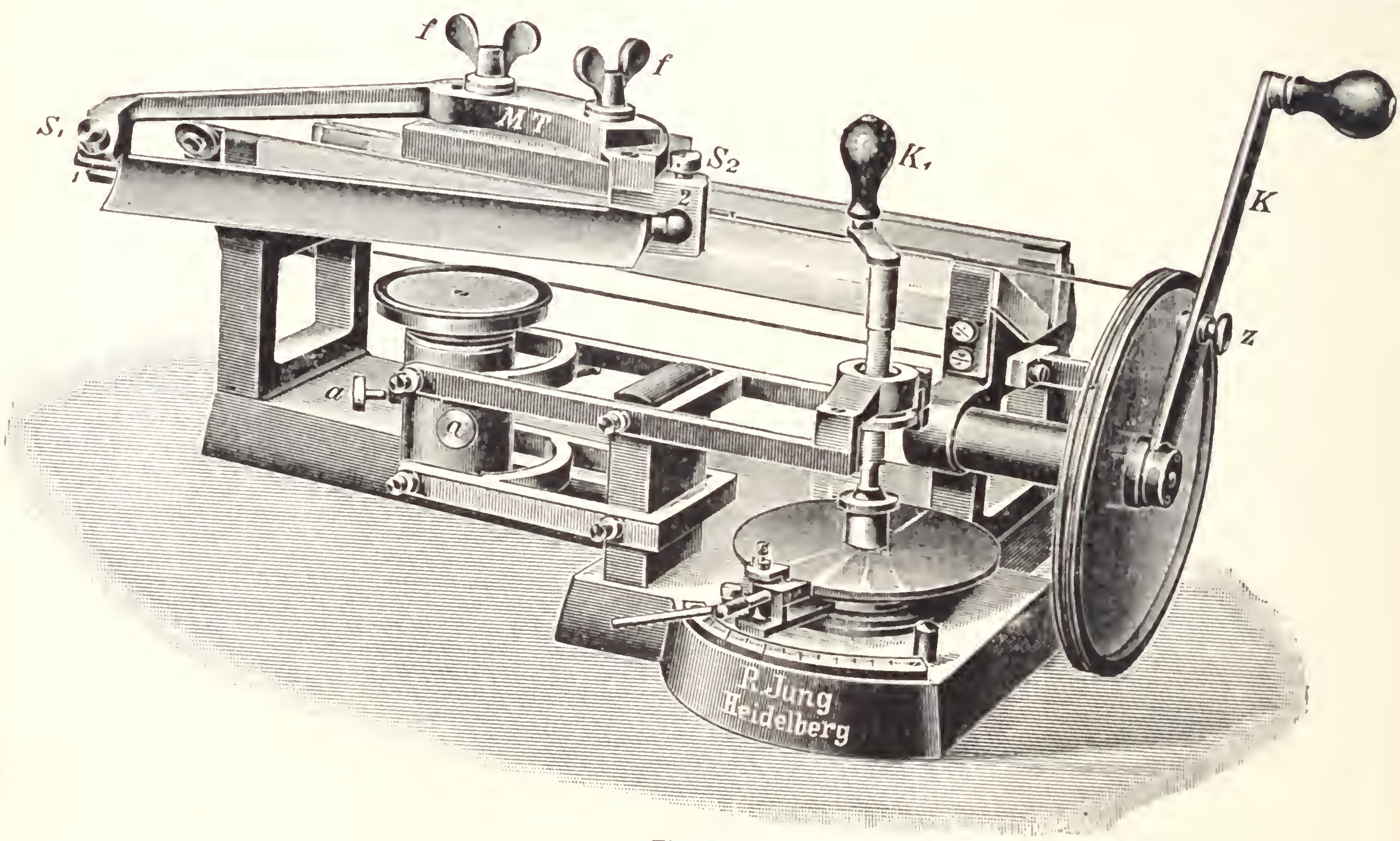


Fig. 1.

2. **Microtome.** N. H. III, fitted with glass slides, in other respects similar to the preceding model, but provided with automatic advance of the object, it is capable of cutting objects not exceeding 70 mm in diameter. The vertical movement of the object amounts to 36 mm. (Fig. 1, in which the trough is not shown for the sake of clearness.)

3. **Microtome.** N. H. IVa, without trough, fitted with glass slides and new orientating object-clamps and freezing apparatus.

4. **Thoma's Microtome.** Model I with simple equipment (Fig. 2).

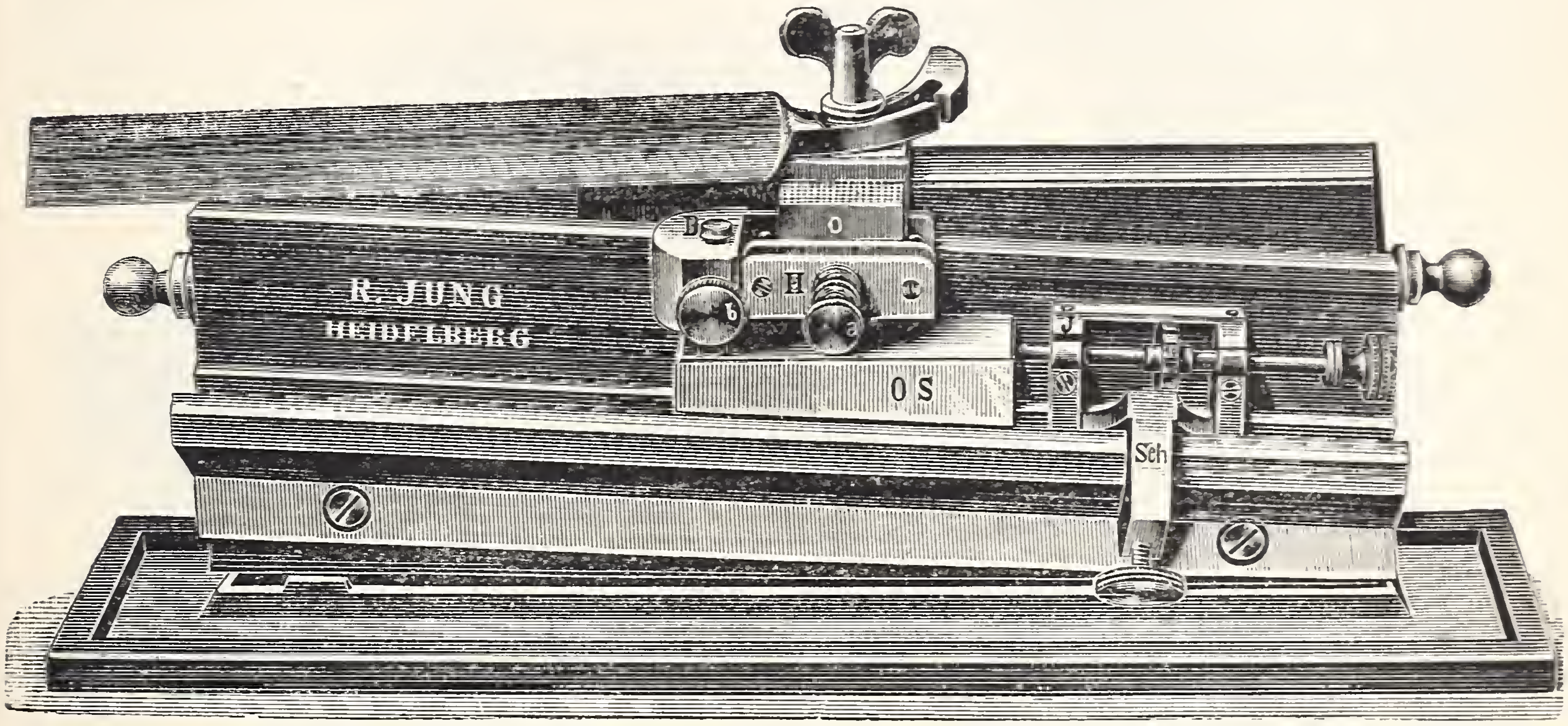


Fig. 2.

5. **Microtome IV,** equipped with items 32, 42, 58 of the firm's catalogue and fitted with new revolving knife-holder for turning the knife about its edge. By means of this holder, the cutting angle

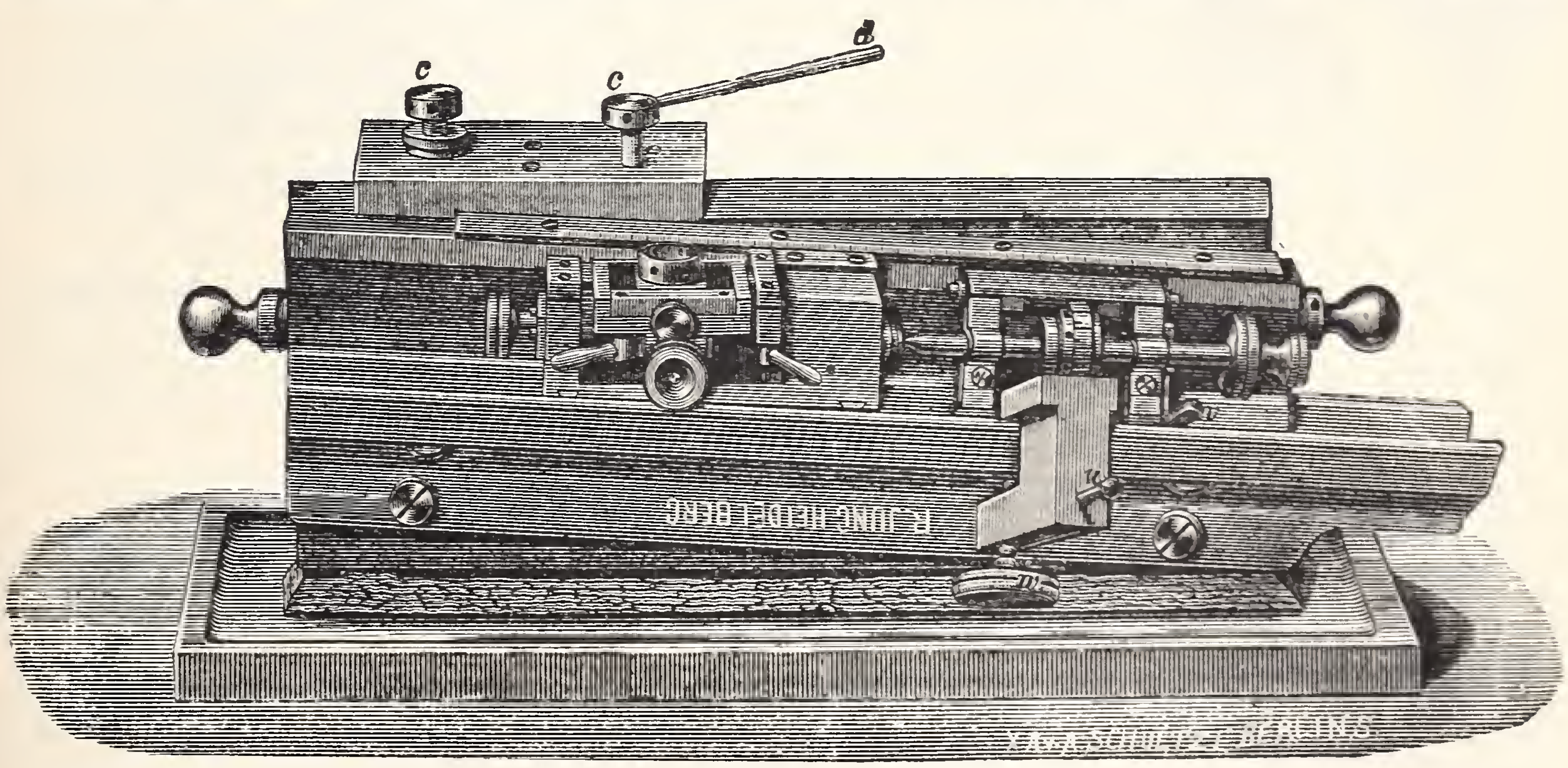


Fig. 3.

may be altered without raising or lowering the edge of knives of a certain width. Wider or narrower knives suffer a certain vertical displacement, which can however be corrected by means of small set screws (Fig. 3).

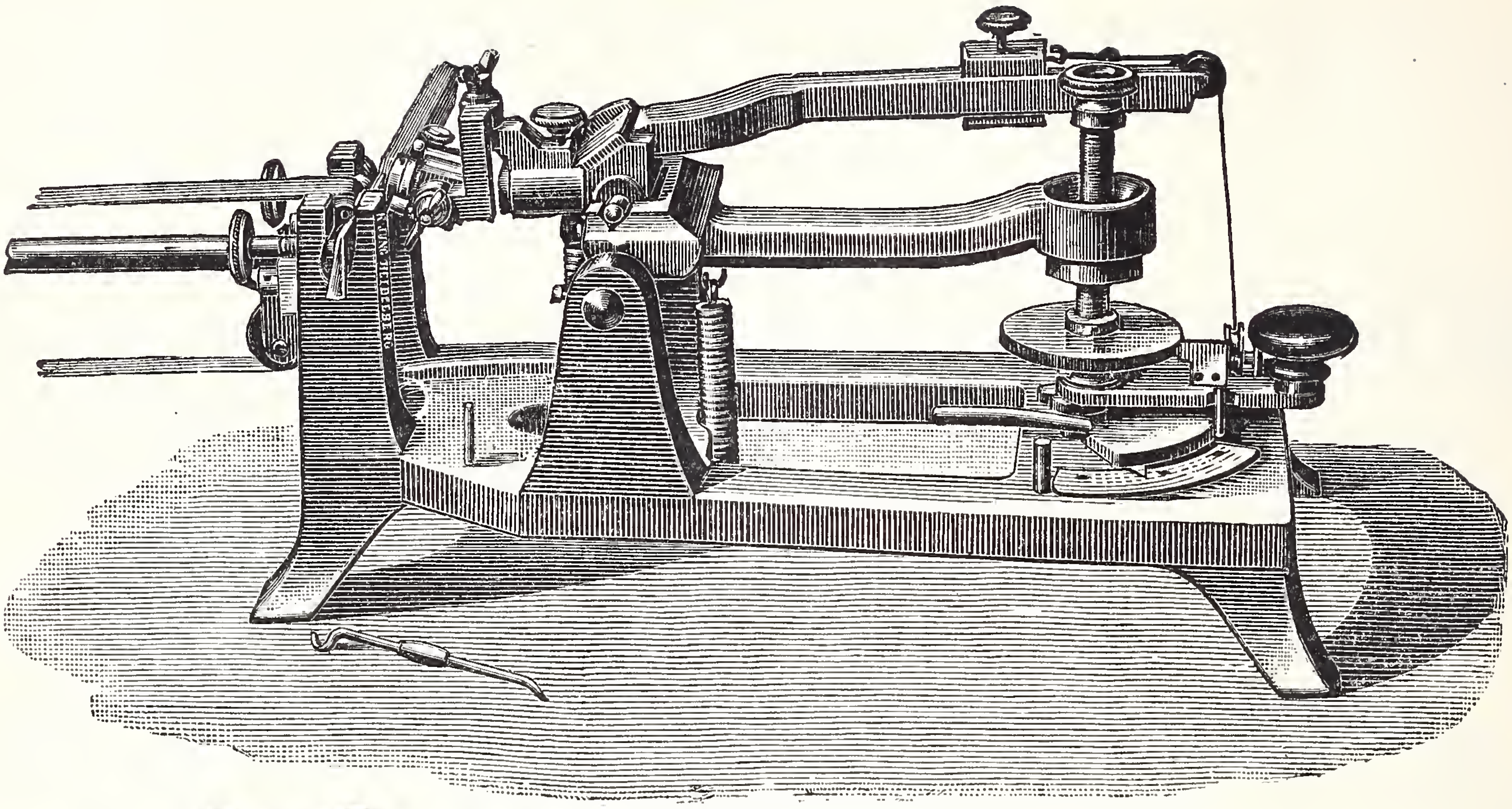


Fig. 4.

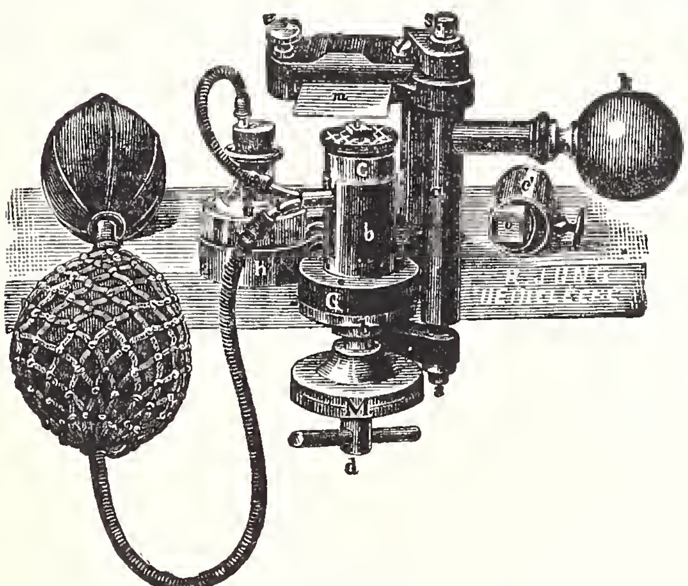


Fig. 5.

6. **Automatic Microtome** for paraffin sections, rocking microtome (Fig. 4).

7. **Automatic Microtome** for paraffin sections, new model.

8. **Small Microtome,** so-called student's microtome, for frozen and paraffin sections (Fig. 5).

9. **Small Microtome,** with automatic adjustment.

10. **Immersion Apparatus** for series sections.

11. **A Set of Brain Sections,** prepared by microtomes N. H. I and II (not for sale).

5. E. Leitz, Wetzlar.

Optical Works.

(See also Section Vd.)

Microscopes.

1. **Stand I,** Fig. 1, inclinable, with clamping lever and circular revolving stage. The coarse adjustment is effected by a rack and pinion movement, the fine adjustment by a micrometer screw with divided head. Draw-tube divided in millimetres. Large illuminating apparatus with cylinder iris-diaphragm and hinged condenser, for rapidly and conveniently interchanging the condenser and cylinder-diaphragm. Revolving nose-piece for the objectives. The microscope is equipped with apochromatic dry lenses 16 mm, 8 mm and 4 mm and an apochromatic 2 mm oil-immersion lens, together with five compensating eyepieces. Magnifications 62 to 2,250.

The Large Microscopes comprising Stand Ia, which is smaller than, but in other respects similar to Stand I; Stand Ia with the English form of foot; Stand Ib with fixed square stage. These micro-

scopes are equipped with the achromatic objectives 3, 6 and oil-immersion $^1/_{12}$" and Huyghenian eyepieces I to V. Magnifications 60 to 1100.

2. **The Medium Sized Microscopes** comprise Stand IIa (Fig. 2) and Stand IIb. These two stands differ with respect to the form of their feet, the former having a horse-shoe foot, the latter a claw-foot. The coarse and fine adjustments are similar to those of the large stands, the draw-tube is divided into millimetres. The illuminating apparatus is of the simplified Babuchin type and is fitted with lateral worm-screw for raising and lowering. The condenser can easily be exchanged for the cylinder-diaphragm. Triple nose-piece for quickly changing the objectives. Objectives 3, 6 and $^1/_{12}$" oil-immersion, and Huyghenian eyepieces I to V. Magnifications 60 to 1100.

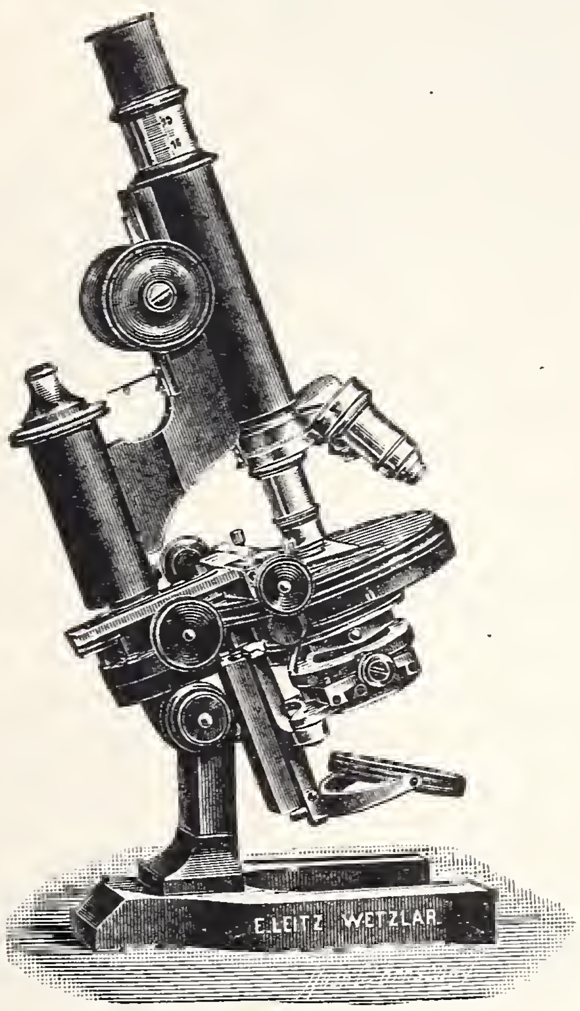


Fig. 1.
Stand I.

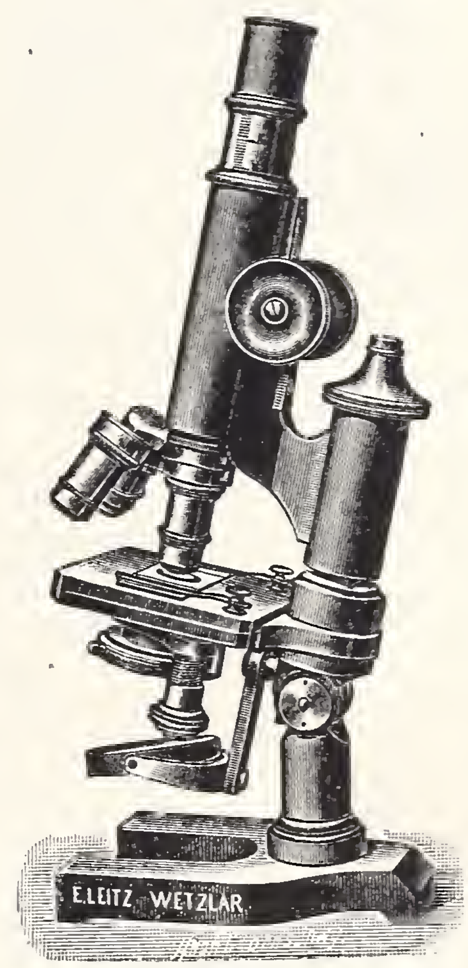


Fig. 2.
Stand IIa.

The Small Microscopes III, IV and V are provided with coarse sliding tube and micrometric fine adjustment. Their optical equipment consists of the achromatic objectives 3 and 7 and the Huyghenian eyepieces I and III. Magnifications 60 to 500.

Stand VI, being solidly constructed, is a useful auxiliary instrument for laboratory and commercial purposes.

3. **Nebelthau's Sliding Microscope** is adapted for searching sections attaining dimensions of 16×20 cm, brain sections in particular, also plate and dish cultures with low and medium powers.

4. **Dölken's Microscope** with large object-stage, adapted for the examination of large preparations with the aid of the condenser in conjunction with the highest powers.

5. **Large Microscope** equipped for mineralogical work. The outfit includes a polarizer and analyzer, revolving graduated stage, divided eyepiece and verniers, eyepieces with cross-lines, quadruple quartz-plate, calcite, selenite and quartz-plates, &c.

6. **Travelling, Reading and Dissecting Microscopes.**

7. **Apparatus for Blood-examination,** consisting of a micro-spectroscope, Thoma's haemacytometer, blood alkalimeter and Ehrlich's eyepiece.

8. **Various Measuring and Drawing Appliances** and other microscopic accessories, including **Microtomes.**

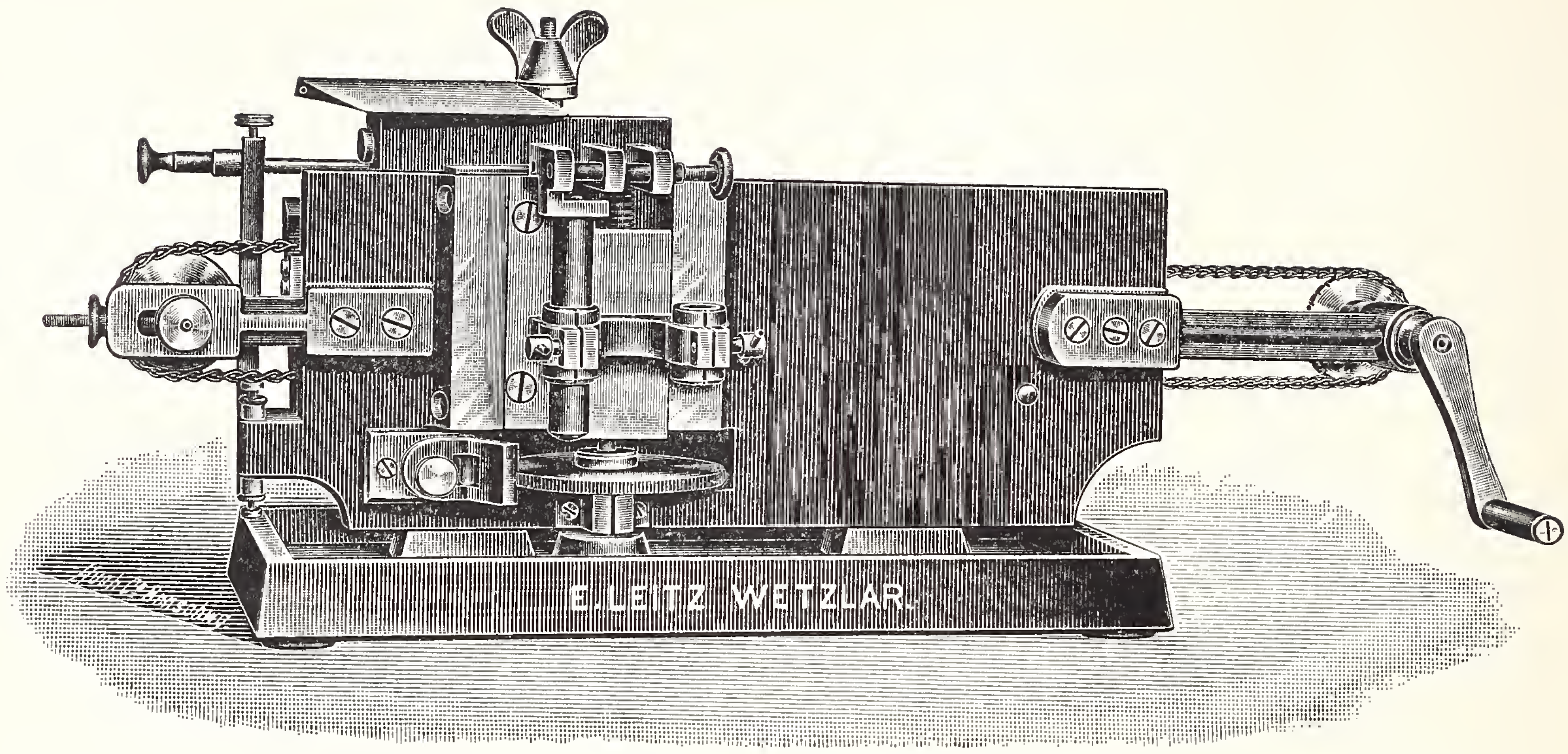


Fig. 3.
Microtome.

These microtomes are all fitted with means for vertically raising the object; the amount of the elevation, i. e., the thickness of the section, is shown by a micrometer-screw. The clamps holding the object are either fixed or movable. The ball-jointed clamp admits of the object being inclined in any direction. The desired position is fixed by a screw.

The Naples clamp serves to adjust the object in two directions, one of these adjustments being effected by a rack and pinion movement, the other by a worm-screw. The microtomes differ in the manner in which the knife-blocks are made to travel. This is effected either by hand or by means of a crank and screw motion, or by a crank-wheel and chain movement. Fig. 3. The object is raised automatically in these microtomes by means of a toothed wheel attached to the micrometer-screw, which is actuated by a ratchet lever worked by the return movement of the knife-block. The lever is adjustable so as to vary the number of teeth engaged by the ratchet from 1 to 10. A movement of the disk by one tooth causes the object to rise 0.0025 mm. A Thoma or Heidelberg knife can be fixed immediately upon the knife-block by means of a wing-nut. The tracks of these microtomes are respectively 42, 32 and 19 cm long.

In the case of the small Hand and Well Microtomes the knife or razor is worked by hand.

6. Gustav Miehe, Hildesheim (Prov. of Hanover).

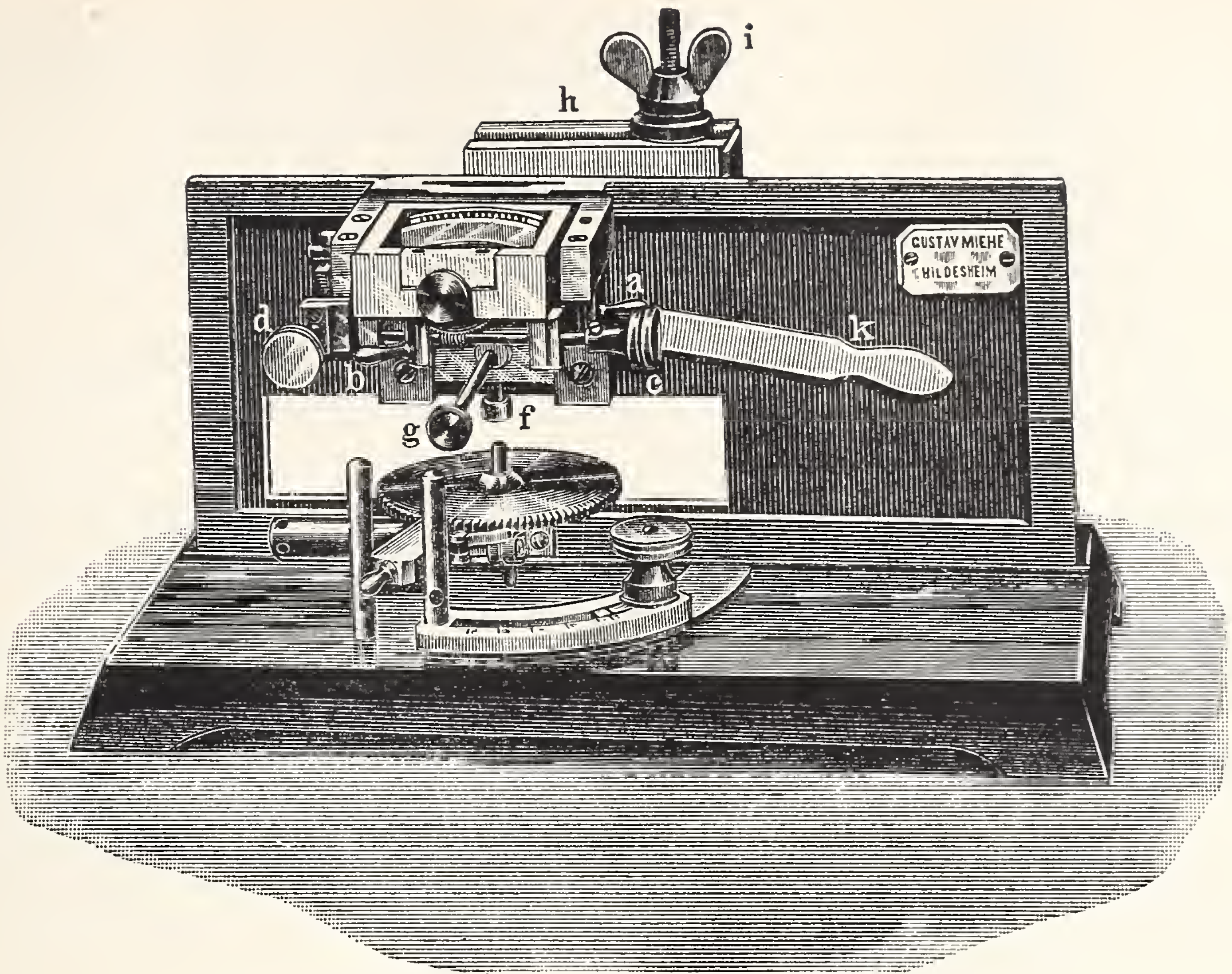
Scientific Instrument Maker.

1. **Microtome** No. 0, with clamp and paraffin stage.
2. **Microtome** No. 1, with clamp and paraffin stage.
3. **Microtome** No. 3, as shown in the illustration, with clamp and paraffin stage.
4. **Microtome** No. 5, as shown in the illustration, with clamp and paraffin stage.

Microtomes Nos. 1, 3 and 5 are fitted with reversible object-holders, which can be rotated on three axes and thereby placed in any desired position.

5. **Microtome** No. 1, mounted on a nickeled sole-plate and fitted with a variable ratchet and pawl adjustment so as to obviate the necessity of reading divisions while cutting. Sections can be cut varying from 0.0025 to 0.2 mm.

6. **Gudden's Microtome** No. 3.



7. **Knife** for ditto, in case.

8. **Knife** in case, 12 cm long.

9. **Knife** in case, 20 cm long.

10. **Dr. Henking's Knife,** in case.

11. **Freezing Apparatus** for microtome No. 3, with filter to obviate the inconveniences arising from stoppage.

12. **Dr. Behrens's Dropping Apparatus** for irrigating the knife while cutting. The supply of fluid is regulated by a small cock. The apparatus is simple and convenient and can be adapted to any microtome.

13. **Prof. Born's Section Stretcher.** This device is simpler and more convenient to use than all other similar appliances.

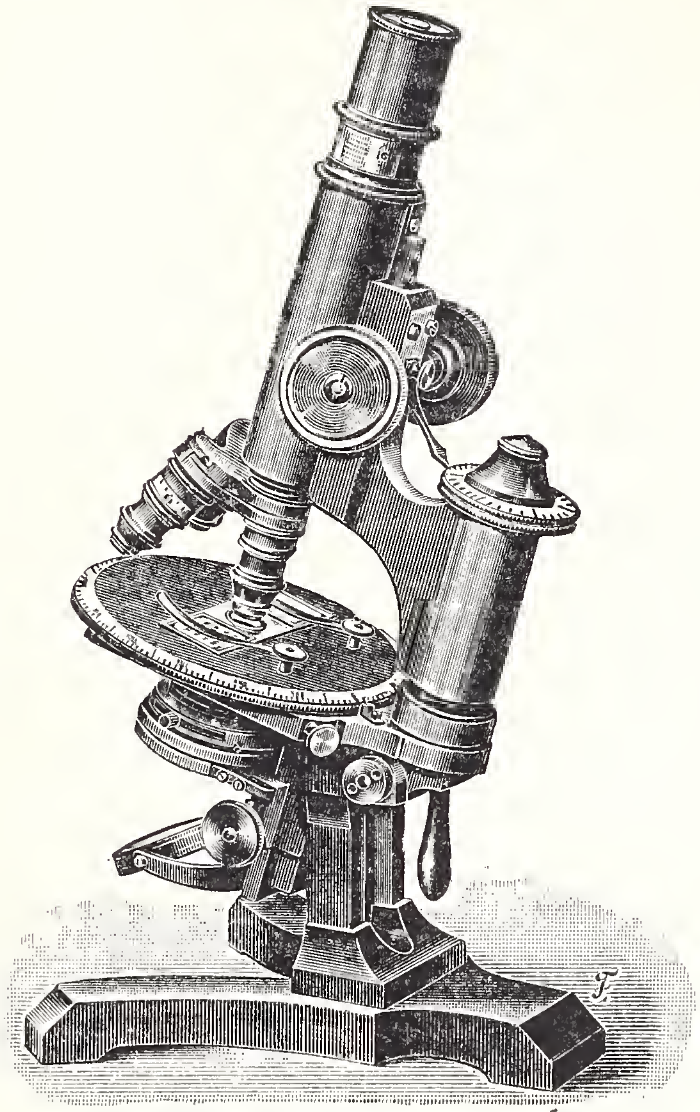
14. **Dr. Luzuki's Block Trimmer,** a very convenient apparatus for accurately squaring and readily adjusting the objects.

15. **Compressor** for meat inspection.

7. W. & H. Seibert, Wetzlar (Rhine Province).

Microscopes and Microscope Accessories.

1. **Stand 2. Large Microscope** fitted with Abbe illuminating apparatus, iris-diaphragm and cylinder iris-diaphragm, revolving nose-piece for three objectives, apochromatic objectives 16, 4, and 2 mm homogeneous immersion, compensating eyepieces 2, 4, 6, 8 and 18, magnifying 21 to 2250 diameters.



Stand 2 (about 1/4 full size).

2. **Stand 3. Large Microscope** fitted with Abbe illuminating apparatus and iris-diaphragm, triple nose-piece, objectives II and V, homogeneous immersion 1/12", eyepieces 1 and 3, magnifying 71 to 1160 diameters.

3. **Stand 4. Large Microscope** fitted with Abbe condenser, triple nose-piece, objectives II and V, homogeneous immersion 1/12", eyepieces 1 and 3, magnifying 71 to 1160 diameters.

4. **Stand 5A** with revolving stage and simplified illuminating apparatus fitted with iris-diaphragm, with triple nose-piece, objectives II and V, homogeneous immersion 1/12", eyepieces 1 and 3, magnifying 71 to 1160 diameters.

5. **Stand 5B** fitted with simplified illuminating apparatus and iris-diaphragm, triple nose-piece, objectives II and V, homogeneous immersion 1/12", eyepieces 1 and 3, magnifying 71 to 1160 diameters.

6. **Stand 6A,** with double nose-piece, objectives II and V, eyepieces 1 and 3, magnifying 71 to 610 diameters.

7. **Stand 6B,** with objectives II and V, eyepieces 1 and 3.

8. **Large Polarizing Microscope,** fitted with polarizer, double condenser, two analyzers, Bertrand lens, &c., eyepieces 0, 1, 2 with cross-lines, 3 with micrometer, objective clamp, objectives 0a, II, IV, V, and homogeneous immersion 1/12".

Detailed illustrated price-list free on application.

8. Paul Waechter, Berlin-Friedenau.

Optical and Mechanical Works.

Established 1872.

(See also Section Ve.)

1. **Microscope Ia,** nose-piece for four objectives, eyepieces 1 to 5, objectives 3, 5, 7 and 1/12 oil-immersion, Abbe illuminating apparatus, &c.

2. **Microscope Ia,** nose-piece for three objectives, three eyepieces, objectives 3, 7 and 1/12 oil-immersion, Abbe illuminating apparatus, &c.

3. **Microscope I,** nose-piece for three objectives, three eyepieces, objectives 3, 7 and 1/12 oil-immersion, Abbe illuminating apparatus, &c.

4. **Microscope I** with revolving stage and polarizing apparatus, one eyepiece, objective 5.

5. **Microscope II,** nose-piece for three objectives, three eyepieces, objectives 3, 7 and 1/12 oil-immersion, Abbe illuminating apparatus, &c.

6. **Microscope II,** nose-piece for two objectives, two eyepieces, objectives 3 and 8, Abbe illuminating apparatus, &c.

7. **Microscope III** with Abbe illuminating apparatus, two eyepieces, objectives 3, 7 and 9.

8. **Microscope IIIa** without illuminating apparatus, two eyepieces, objectives 3 and 7.

9. **Microscope IVa,** nose-piece for three objectives, three eyepieces, objectives 3, 7 and 1/12 oil-immersion, Abbe illuminating apparatus, &c.

10. Microscope IVa, two eyepieces, objectives 3 and 7.
11. Microscope V, one eyepiece, objective 5 (1+2+3).
12. Microscope Va (trichinoscope).
13. Microscope VI, one eyepiece, objective 5 (1+2+3).
14. Microscope X, one eyepiece, objective 4 (1+2).
15. Microscope XIII (trichinoscope).
16. Microscope Vb, to fold up, for country meat inspectors.

Various small school, demonstration and dissecting microscopes, magnifiers and accessory appliances.

9. Carl Zeiss, Optical Works, Jena.

(See also Sections II, Vb, Vd, Ve and Vf.)

Microscopes and Microscope Accessories.

The old empirical system of constructing microscope objectives has been discarded by this firm since thirty years, and thenceforward manufacture has been preceded by the complete computation of the whole of the data required for optical construction. The establishment of new test methods necessitated by this system led in its earliest stages to the construction of an illuminating apparatus,

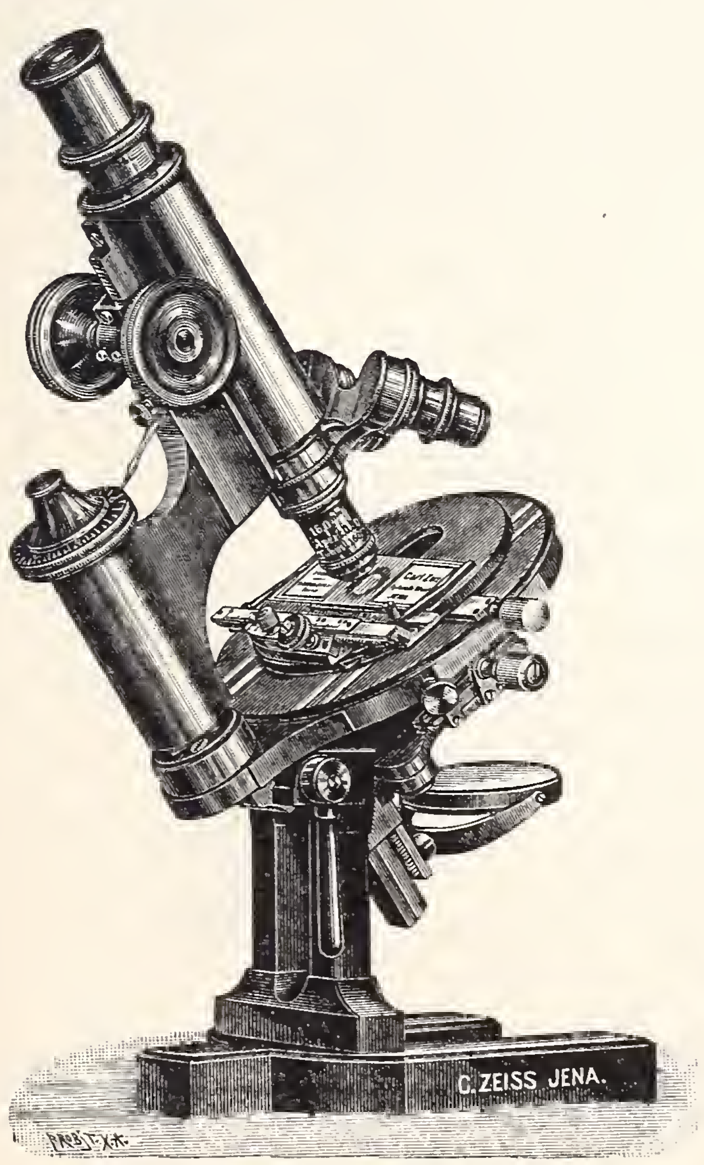


Fig. 1.
Stand Ia with large mechanical stage.

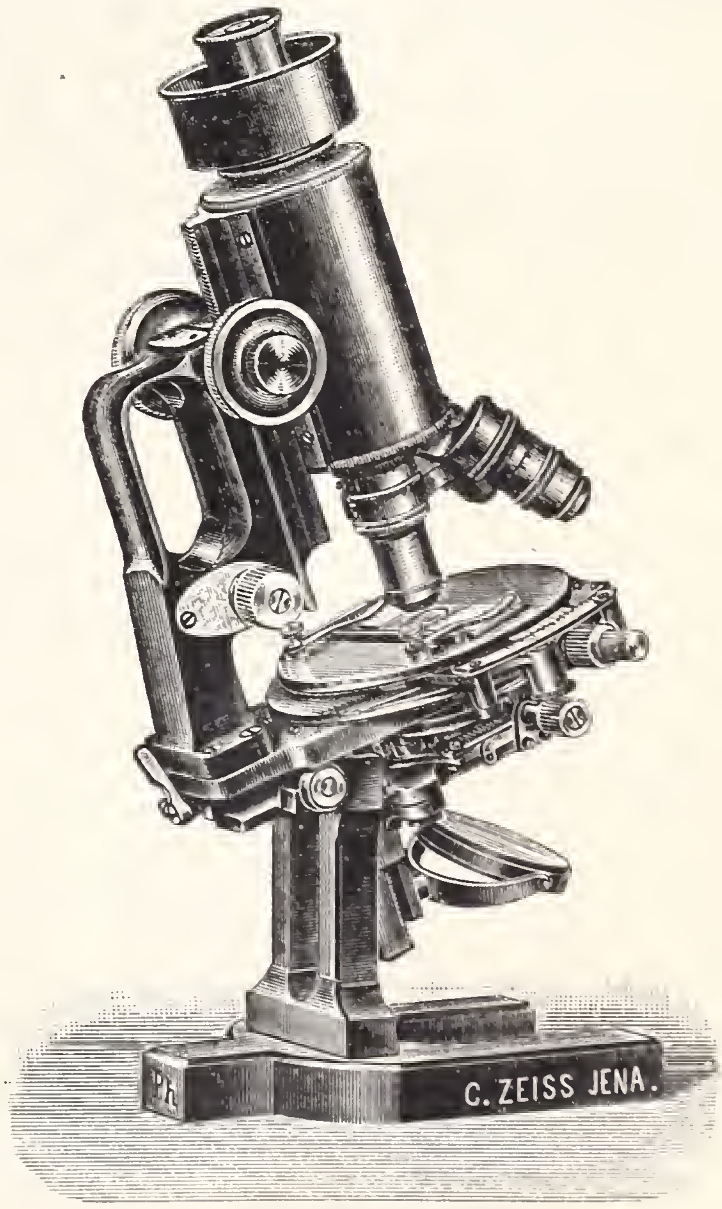


Fig. 2.
Stand for projection and photo-micrography, with Berger's body-frame.

which, in conjunction with suitable stops, sufficed to produce all the phases of direct and oblique illumination. This apparatus has subsequently come into much more general use as a microscope adjunct and has been known as "Abbe's illuminating apparatus."

Ever since the true connection between the aperture and resolving power of an objective became elucidated by Abbe's theory of the microscope, it has been the prominent aim of opticians, seeking to improve microscope objectives, to increase their numerical aperture. These efforts have led to the construction of homogeneous immersion lenses, which originated in the Zeiss works and was subsequently followed by a mono-bromide of naphthaline immersion lens yielding a numerical aperture of 1.6.

In addition, the optical resources of the microscope were considerably increased by the introduction of numerous new kinds of glasses, which, by suitable selection, furnished the means of neutralizing the secondary spectrum and the chromatic difference of spherical aberration. The practical result of these efforts, which originally proceeded from purely theoretical considerations, was the introduction of the apochromatic objectives and a considerable improvement, with the aid of the new glasses, of the achromatic objectives. These improvements extended also to the eyepieces, inasmuch as it had become possible to compensate by suitably computed eyepieces the chromatic difference of magnification, which constituted a residual defect in all high power objectives, including the apochromatic lenses. These eyepieces were called compensating eyepieces.

Another series, the projection eyepieces, was constructed for the purpose of improving the real images projected on the screen by the objective and eyepiece.

The firm contributed also to the development of the binocular microscope and introduced, in the shape of Greenough's microscope, an instrument which is capable of yielding true and practically useful stereoscopic vision.

Concurrently with the optical improvements the firm steadily developed the mechanical details and workmanship of the microscope stands, with the principal object of perfecting the precision of the adjustments. Recently a stand has been designed having its upper body constructed on a new principle.

A. Objectives. Complete series of the Apochromatic Objectives and Compensating Eyepieces. Complete series of the Achromatic Objectives and Huyghenian Eyepieces. Auxiliary appliances for testing microscope objectives. New aplanatic projection lenses of 35 and 70 mm focus. Plankton searcher.

B. Stands. (Figs. 1 and 2.) Complete series of microscope stands for general use. New: Stand for Projection and Photo-micrography, fitted with M. Berger's body-frame. Stand for Brain-sections having a stage of 25×25 cm. Mineralogical Stand.

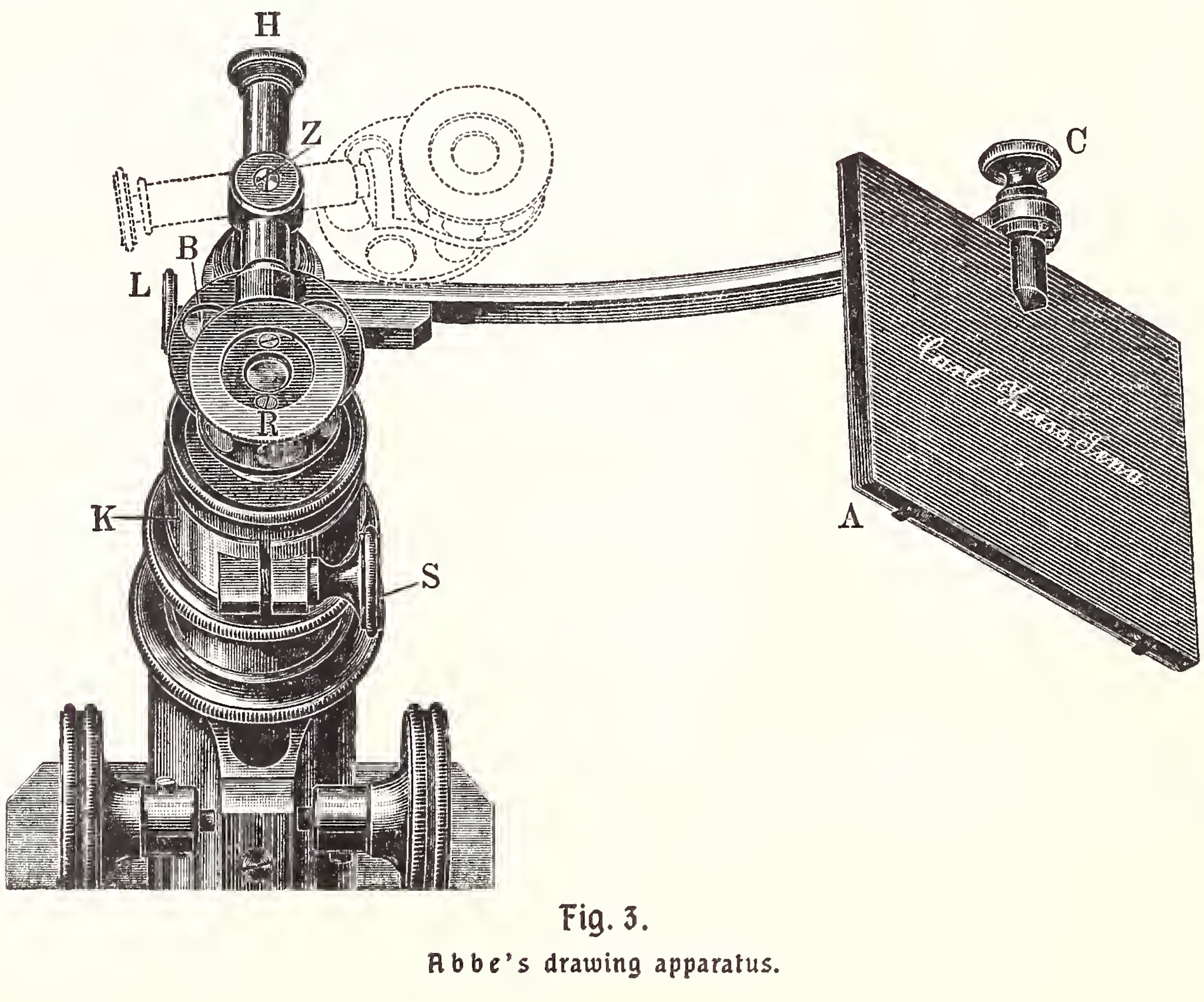


Fig. 3.
Abbe's drawing apparatus.

C. Auxiliary Microscope Appliances. Illuminating appliances for white and coloured light. Spectrum eyepieces. Measuring and counting appliances for microscopical objects (e. g. blood-corpuscle counting chamber). Drawing cameras (Fig. 3). Stereoscopic eyepiece.

D. Dissecting Microscopes and Lenses. New: Greenough's Stereoscopic Dissecting Microscope (Fig. 4). The same, fitted with Braus-Drüner's universal stand. The same equipped as a corneal and skin microscope (dermatoscope). Auxiliary appliances for examining microscopical objects from all sides (Greenough's Prismatic and Capillary Rotators).

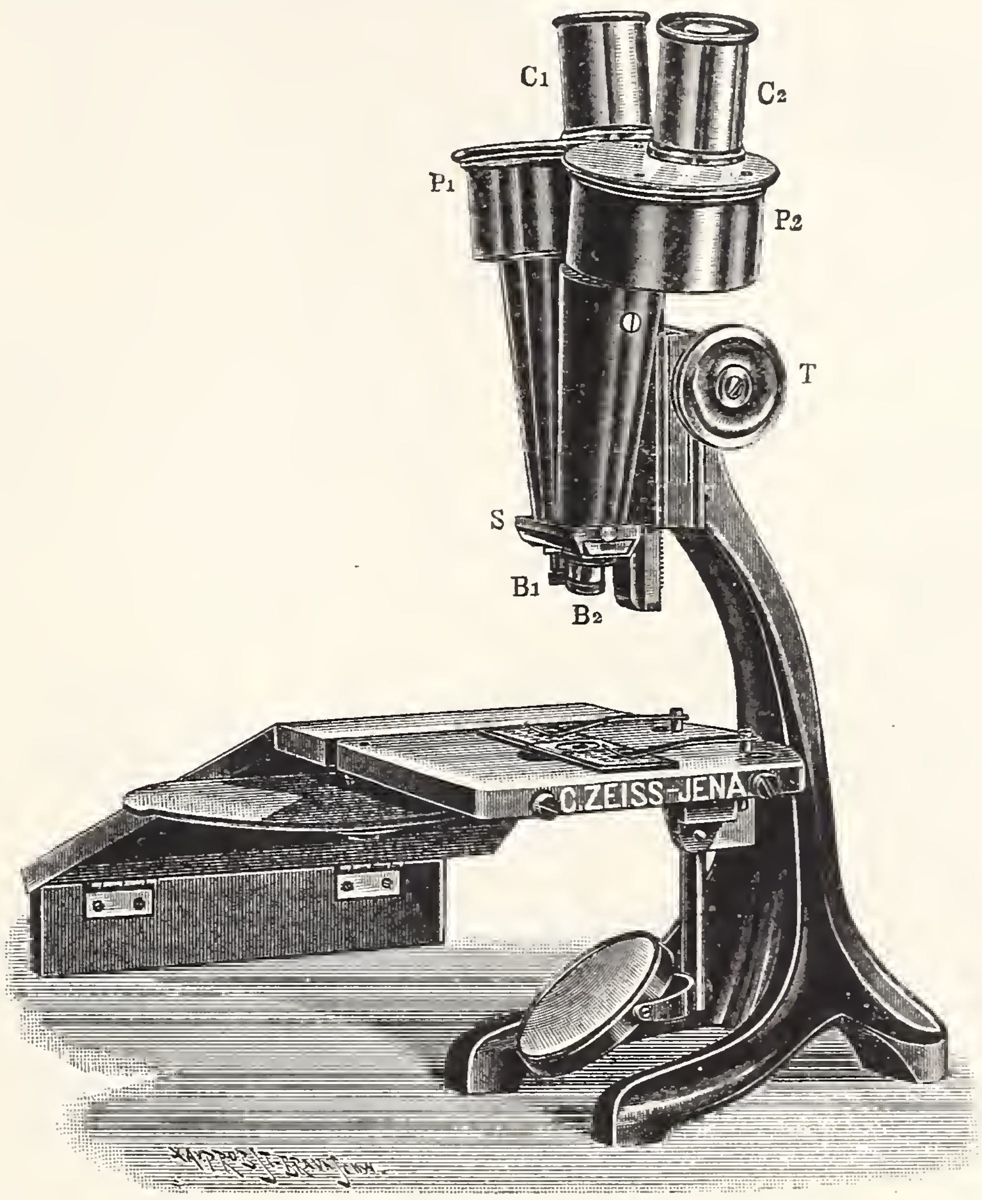


Fig. 4.
Greenough's binocular microscope.

Detailed description in Catalogue No. 31 (1898) of Microscopes and Microscope Accessories, which may be had free on application in French, German or English.

d. Photo-micrography and Projection.

1. R. Fuess, late J. G. Greiner jr. & Geissler,

Steglitz near Berlin, 7/8 Düntherstr.

Mechanical and Optical Works.

(See also Sections IIIa, IV, Vb and Vg.)

1. **Projection Apparatus for electric light** with triple condenser of 125 mm diameter. (C. Leiss, Die optischen Instrumente, &c., p. 336.) Fig. 1.

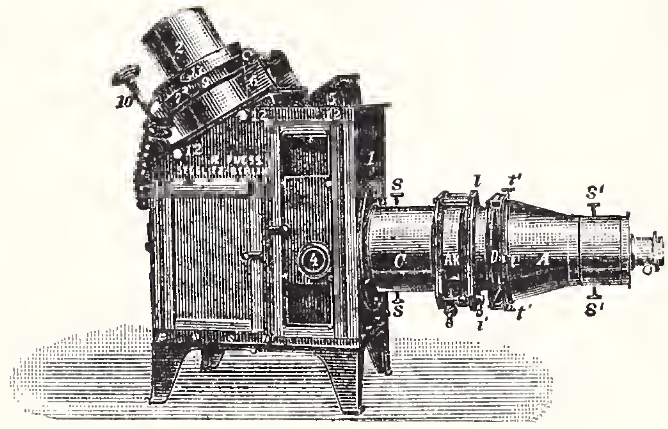


Fig. 1.

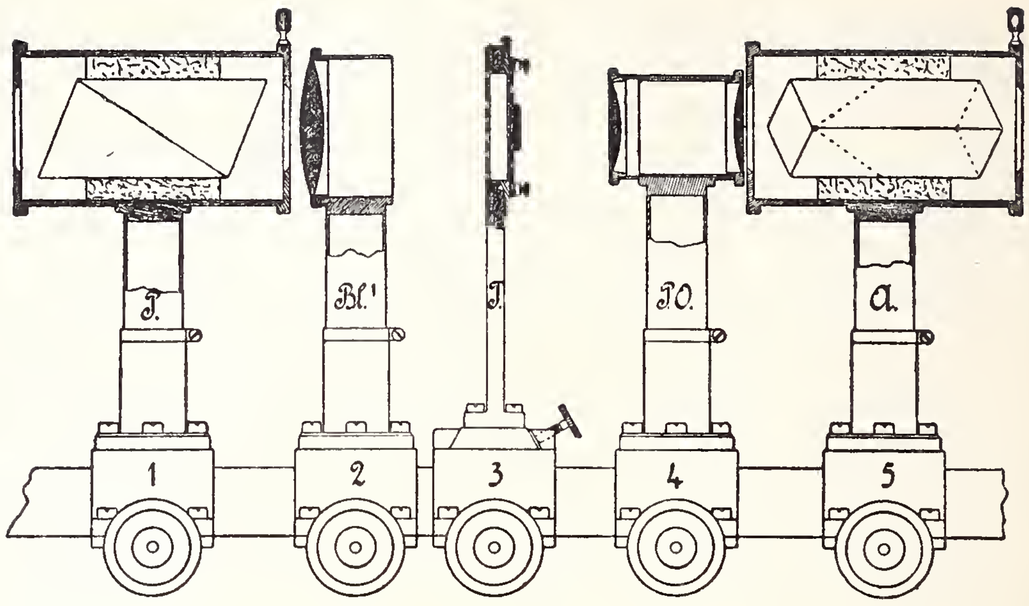


Fig. 2.

2. Projection Apparatus for physical and crystalloptic demonstrations. (C. Zeiss, ibid. p. 336.) Figs. 2 and 3.

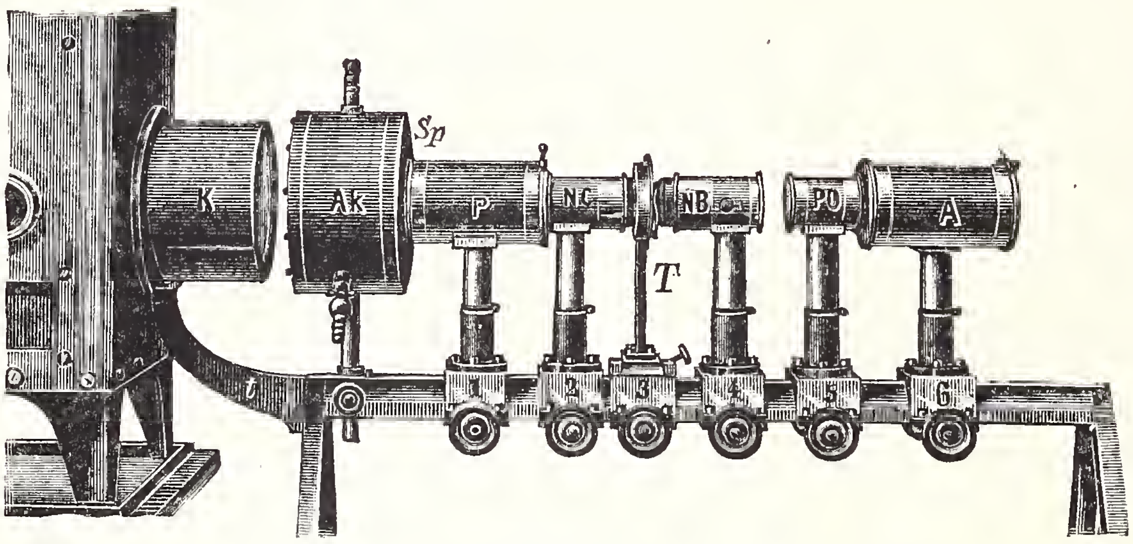


Fig. 3.

2. A. Krüss (Proprietor Dr. Hugo Krüss), Hamburg,

7 Adolphsbrücke.

Established 1796.

Optical Institute: Spectrum Apparatus, Prisms, Photometers, Projection Apparatus, Sciopticons, Lantern Slides.

[See also Sections Va, Vb and VIII.]

1. Projection Apparatus worked by electric light, adapted for lantern slides, microscopic objects, spectrum experiments, &c. Fig. 1.

2. Large Projection-lamp with illuminating lenses for pictures not exceeding 150 mm in diameter, with cooling trough and achromatic objective for lime-light or electric light. Fig. 2.

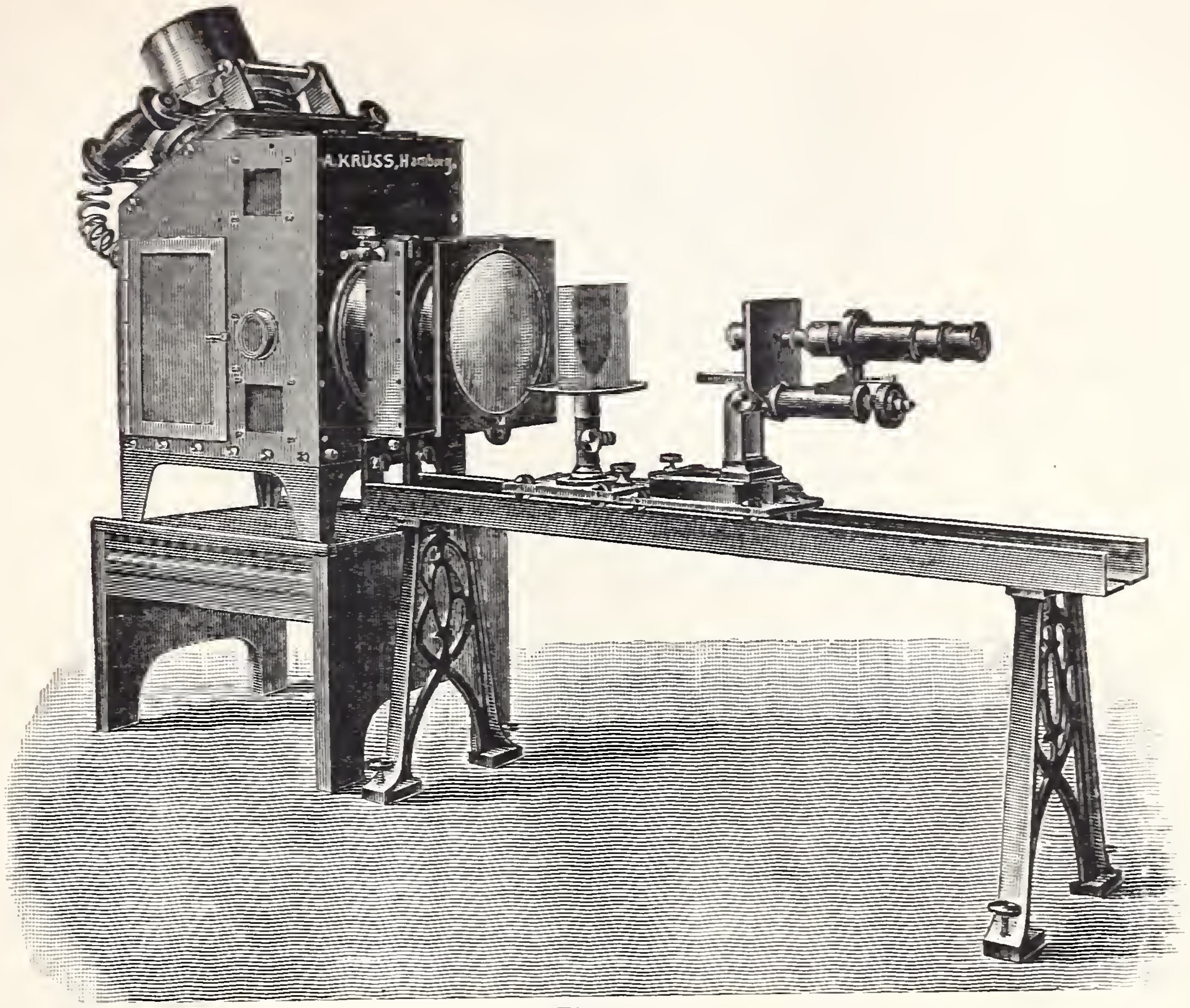


Fig. 1.

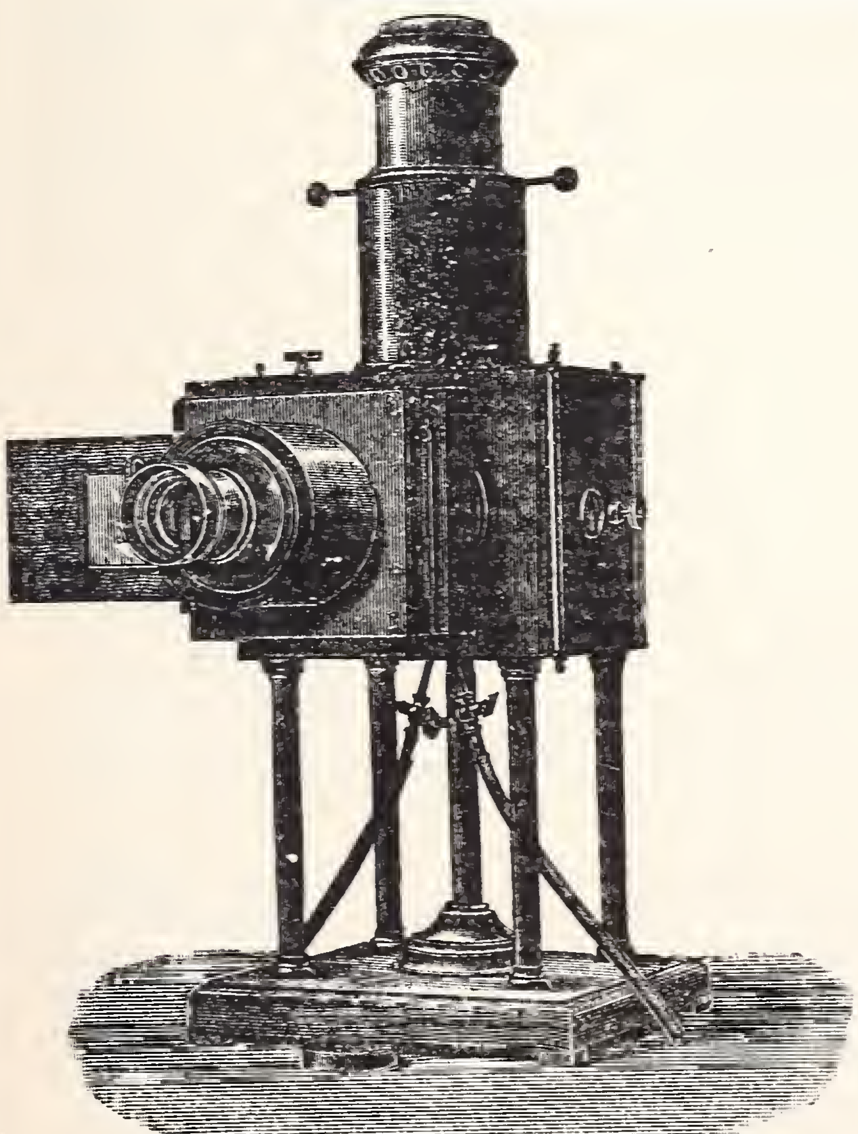


Fig. 2.

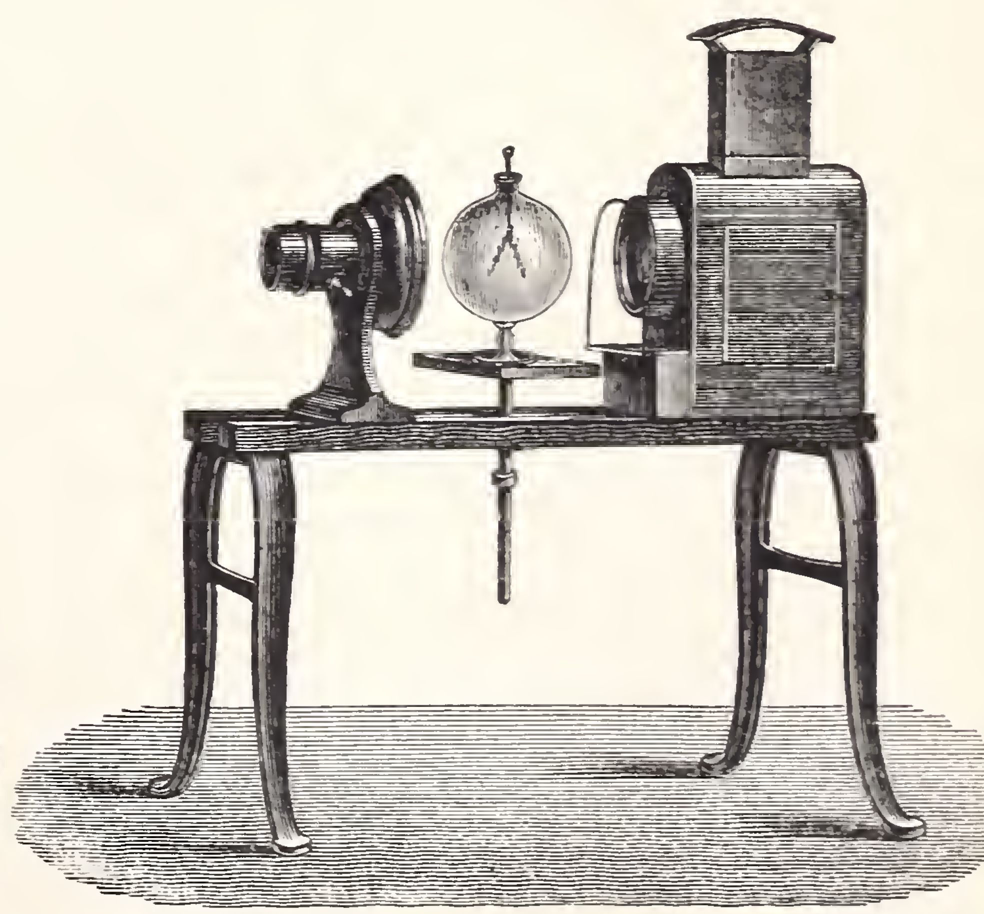


Fig. 3.

3. **Sciopticon,** mounted on optical bench, for demonstrating physical and chemical experiments and for showing lantern slides. Fitted with triple burner petroleum lamp. Fig. 3.

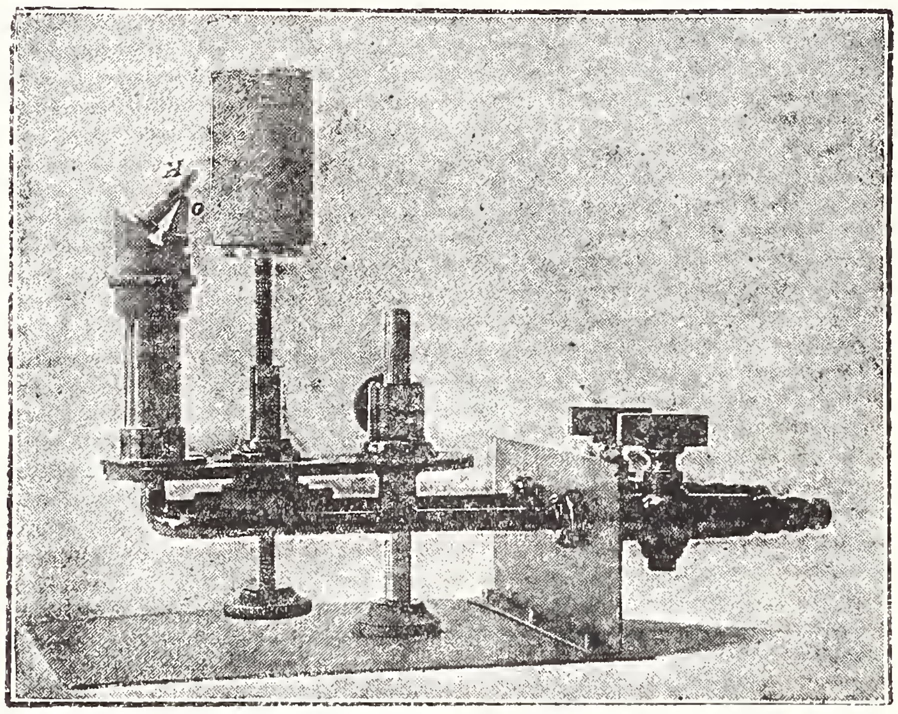


Fig. 4.

4. **Lime-light Burner** of original construction, absolutely reliable (Prometheus 7. 112. 1896), for sciopticons. Fig. 4.

3. E. Leitz, Wetzlar.

Optical Works.

(See also Section Vc.)

I. Photo-macrographic and Photo-micrographic Appliances.

The exhibits comprise two forms of photographic apparatus:—

1. Edinger's Apparatus for low magnifications.
2. A Photo-micrographic Apparatus for high magnifications.

1. **Edinger's Apparatus** is adapted for photographing objects measuring 8 to 35 mm in diameter at magnifications of 3 to 20 diameters. Special photographic lenses of 24, 42 and 64 mm focus have been constructed for this purpose. The 24 mm lens has a covering power of 13×18 cm, the 42 mm lens covers 18×24 cm and the 64 mm lens 24×30 cm. These plates are uniformly and sharply covered up to the edge.

2. **The Photo-micrographic Apparatus** is used in conjunction with the microscope. The construction of the apparatus, which is used in a vertical position, is shown in Fig. 1. Whereas with a horizontal microscope it is customary not to use eyepieces, this apparatus is intended for use with any of the eyepieces, so as to yield magnifications up to 1200 diameters. It is adapted for 9×12 cm and 13×18 cm plates. The achromatic objectives are sufficient in every respect, although some microscopists give preference to apochromatic lenses.

These appliances are more fully described in a pamphlet entitled:—"Die mikrophotographischen Apparate der optischen Werkstätte von E. Leitz. Anleitung zum Gebrauch dieser Apparate mit einer photographischen Technik."

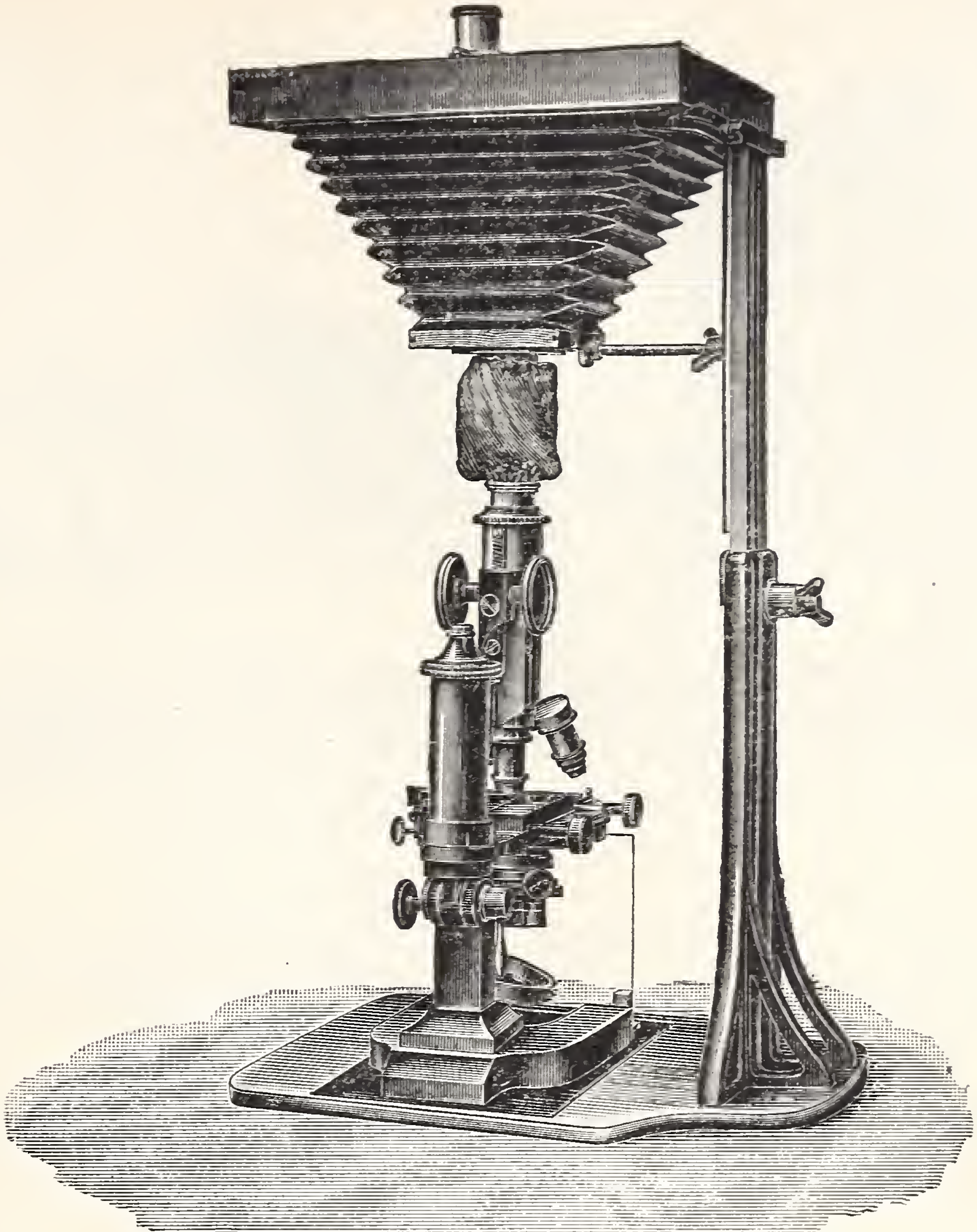


Fig. 1.

II. Projection Appliances.

Large Projection Apparatus. This apparatus is adapted: a. for projecting lantern slides on the screen; b. for the projection of microscopical preparations; c. for endoscopic projection, and d. for physical demonstrations.

The specification includes for all these purposes:—

1. a Schuckert projection-lamp of 12 to 20 ampères;
2. a triple condenser of 160 mm aperture;
3. a large cooling trough.

For projection on the screen, the apparatus is supplied with an additional frame for lantern slides and a projection-lens of 300 mm focus. A small condenser fitted with diaphragms, an object-stage and objective-carrier with lenses complete the equipment for microscopic projection. The optical quality and light-gathering power of the condensers render the whole of the microscope objectives, including the $^1/_{12}$ oil-immersion lenses, available for the purposes of projection. At maximum magnifications of about 20,000 diameters the image is sufficiently bright at a distance of 4 m as to be visible to a fairly large audience. Endoscopic projection necessitates a special modification of the illuminating cone, so as to obtain sufficiently bright images of solid objects, internal organs, &c. by incident light. For this mode of illumination, it is necessary to employ an endoscopic light-modifier and a projection-lens of 500 mm focus.

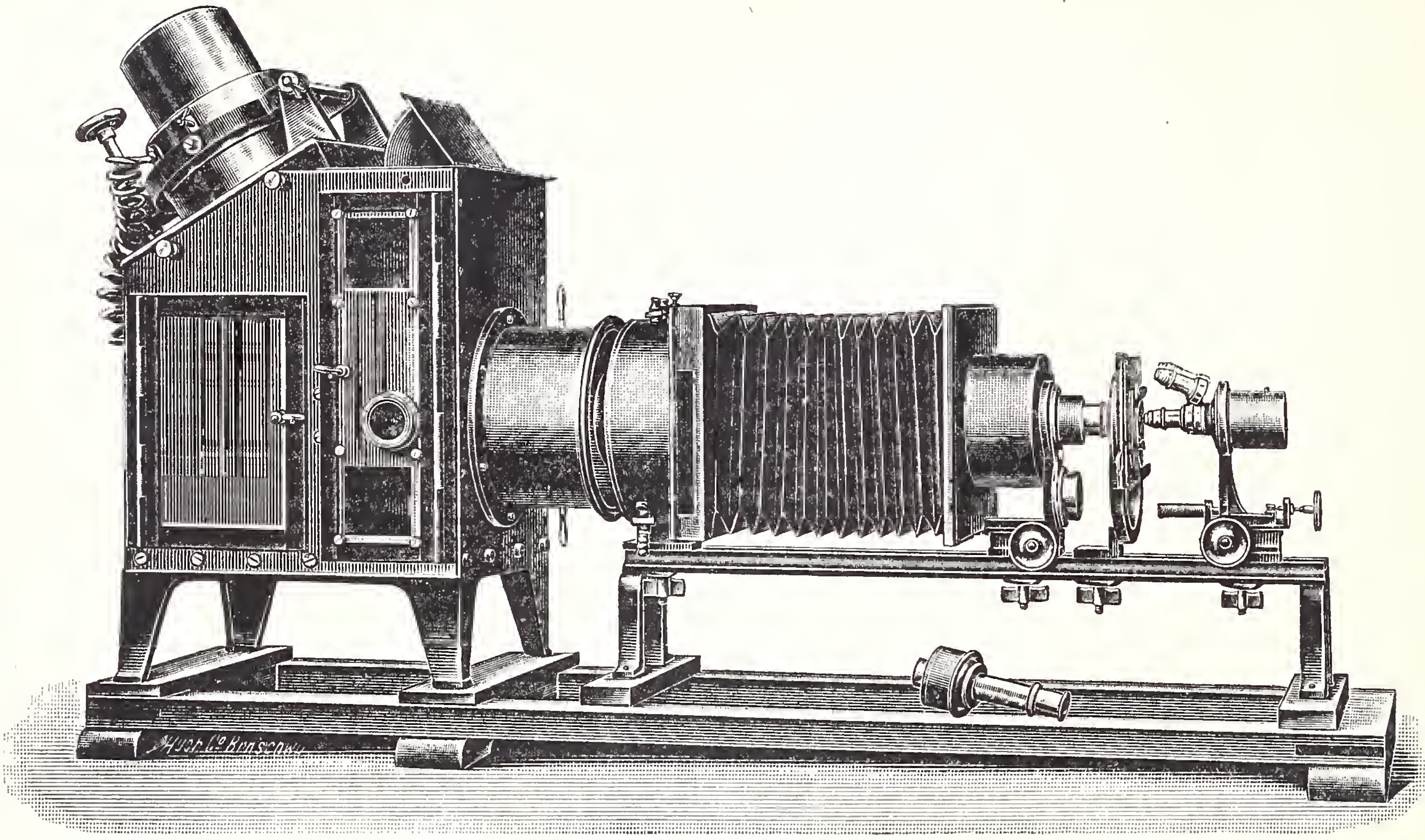


Fig. 2.

A detailed description of these appliances and information on the application of the apparatus for physical demonstrations will be found in a pamphlet entitled:—"Der grosse Projektionsapparat in seinen verschiedenen Verwendungen."

4. Fr. Schmidt & Haensch, Berlin S., 4 Stallschreiberstr.

Optical Works.

(See also Sections Va, Vb and VIII.)

The following are the most important applications of projection appliances:—

1. Projection of lantern slides, which are placed in the slide carrier (D, Fig. 3).
2. Projection of small objects, such as a gold-leaf electroscope, which can be placed near the plane of the lantern slides after removing the bellows (B, Fig. 3).
3. The illumination of optical instruments, e. g. of a Jamin interferential refractometer, for the purpose of demonstration on the screen.
4. Combination of the projection apparatus with an optical bench fitted with various optical appliances, such as the simple microscope, polarizing appliances, spectroscopes, &c.
5. Projection of horizontal objects, e. g. a glass plate with iron filings in the magnetic field of force, as shown in Fig. 1.
6. Projection of opaque objects by incident light, e. g. small illustrations in text-books.
7. Micro-projection.
8. Photo-micrography.
9. Photographic enlargements of negatives.

The exhibits include:—

1. Special Appliances for the Projection of Lantern Slides:—

Travelling Apparatus:

a) With lime-light lamp.
b) With small electric arc lamp, the projection head being designed so as to fold up after the manner of a photographic camera.

Apparatus for Lecture Theatres:

c) Camera of original construction with Hefner-Alteneck arc-lamp (Fig. 2). The camera is lined with asbestos, is impenetrable to light, coated with dulled nickel and presents an unusually elegant appearance.
d) Schuckert camera with projection head similar to c. Fig. 2.

2. Projection Apparatus for Colleges, adapted for the purposes specified under 1, 2, 3 and 4.

a) With lime-light lamp.
b) With small electric arc-lamp.

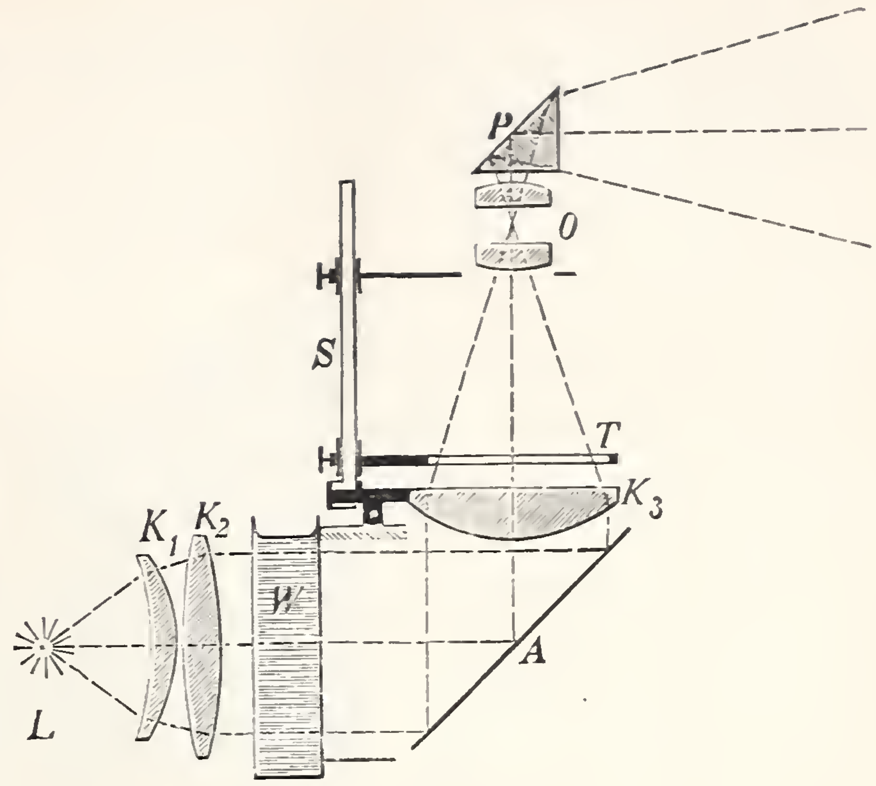


Fig. 1.
Horizontal projection.

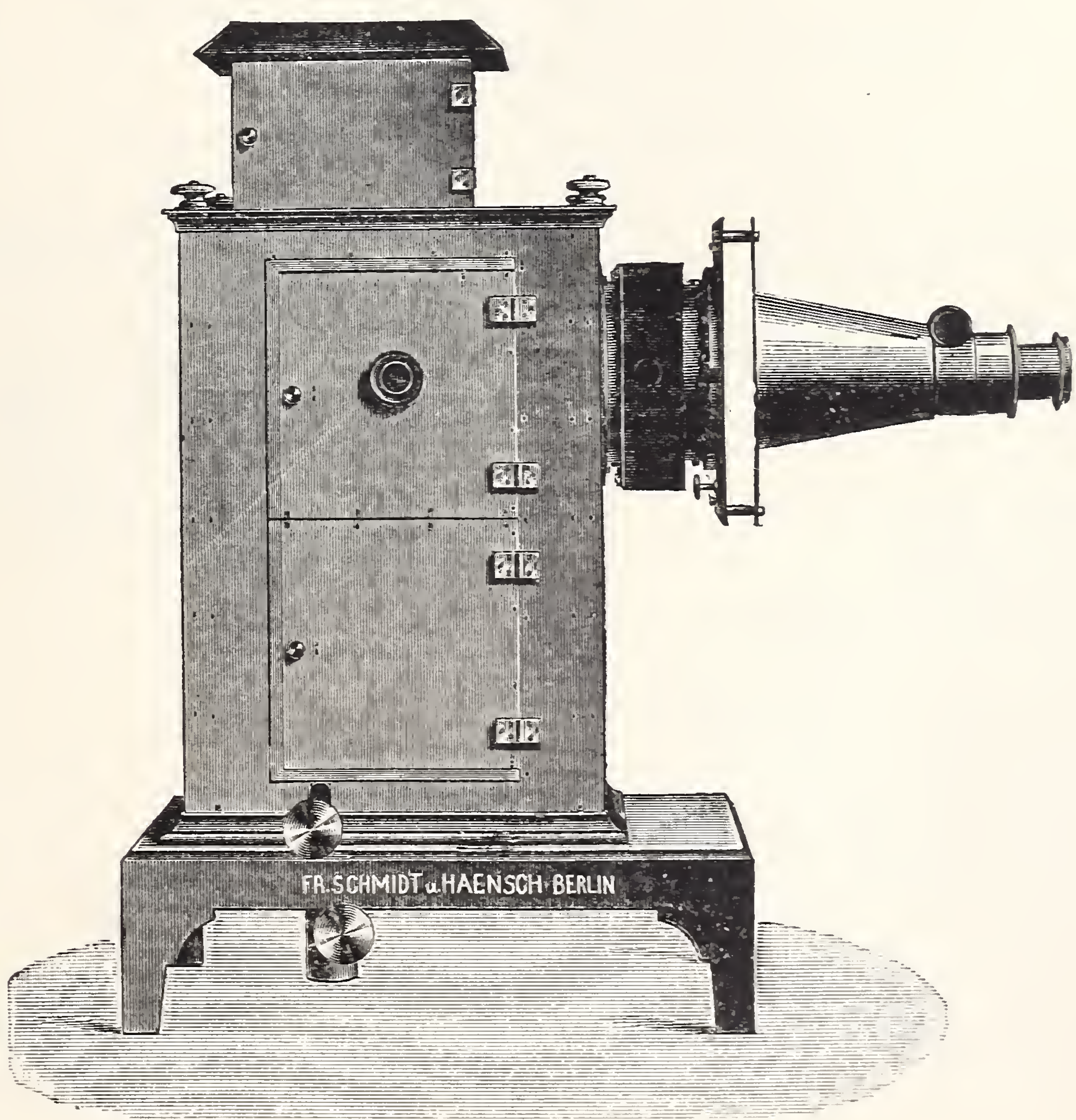


Fig. 2.
Projection apparatus for lecture theatres.

3. Universal Projection Apparatus.

Apparatus with projection-lens O (Fig. 3) in sliding tube, available for the modes of application specified under 1 to 8.

a) Schuckert camera, see Fig. 3.
b) Camera of original construction.

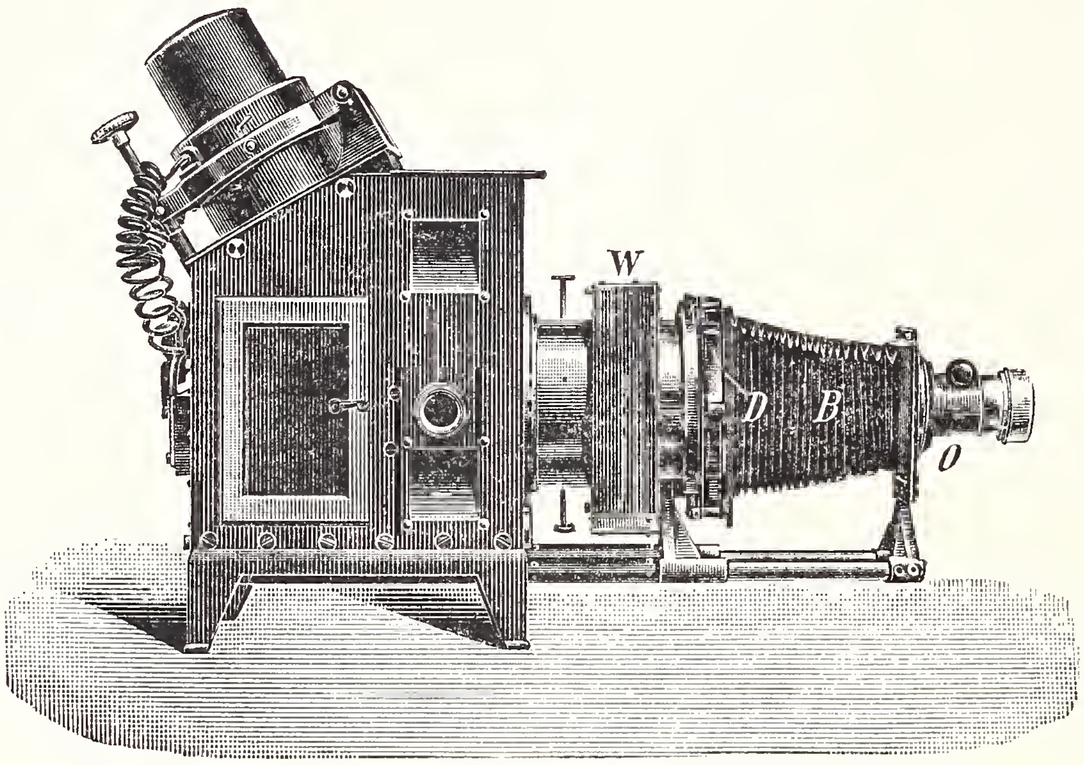


Fig. 3.
Schuckert camera with lens in sliding tube.

Apparatus with projection-lens mounted on rotating guide rod, as shown in Fig. 1, likewise available for the purposes specified under 1 to 8 and adapted for rapid changes of the mode of application:—

c) Schuckert camera. This camera is largely used in physical lecture theatres, mounted as shown in Fig. 4 on a long board fitted with a sunk rail.
d) Camera of original design, matted and nickel-plated and more elegant in appearance than c.

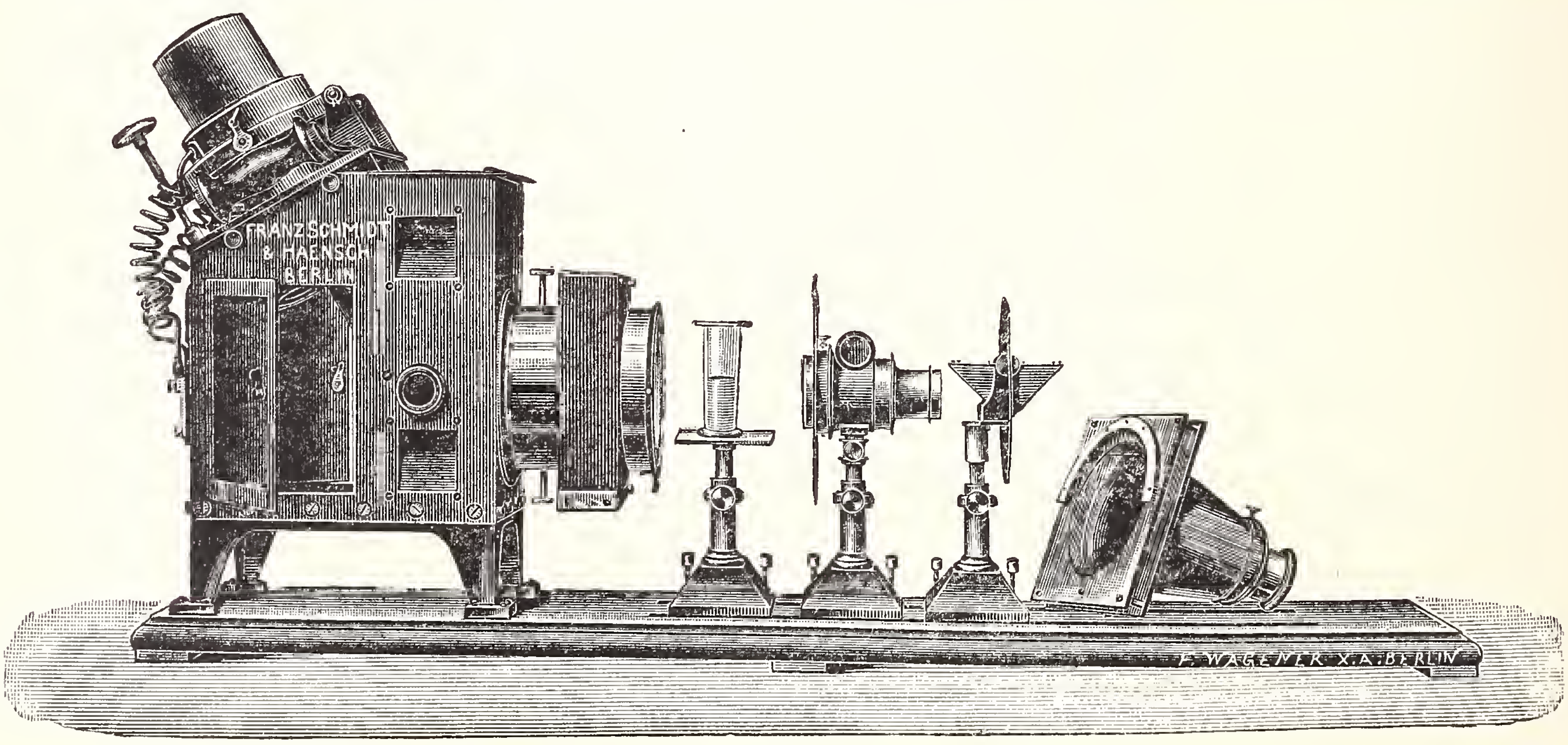


Fig. 4.
Universal projection apparatus on sole-plate with embedded rail.

4. Special Instruments for Projection on the Screen, available for the illumination of optical instruments, e. g. gold-leaf electroscope, Jamin's interferential refractometer with two glass troughs, one of which can be evacuated, Newton's lens on plane glass, direct-vision prisms and other appliances, together with the necessary stands.

5. Optical Benches for Demonstrating Physical Experiments:—

a) Sole-plate with embedded rail (see Fig. 4).
b) Small optical bench.
c) Large optical bench, see Müller-Pouillet's Lehrbuch der Physik, 9th edit., Brunswick, publ. by Fr. Vieweg & Sohn, 1898.
These optical benches are fitted with six sliding riders.
d) Demonstrating appliances for optical benches, made to fit the riders of any of the latter, e. g. parts of a simple microscope, or polarizing apparatus with quartz wedge compensator, spectroscope, &c.

6. Optical Bench with large Microscope. The microscope stands on a slide which can be moved longitudinally and transversely so as to facilitate the rapid transition from the projection of

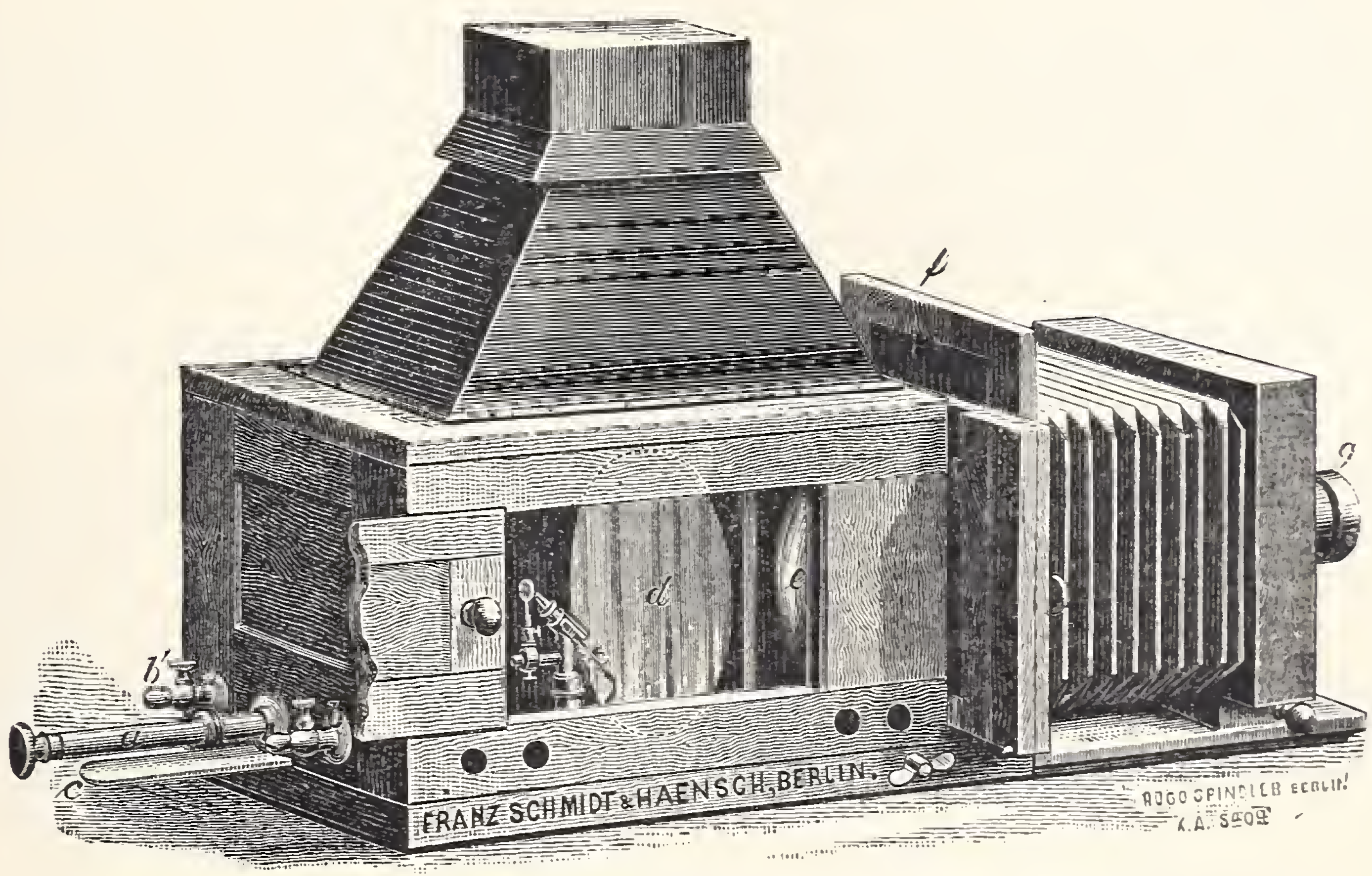


Fig. 5.
Apparatus or enlarging in the dark-room.

lantern slides to microscope projection. These microscopes are, as a rule, equipped with objectives made by Carl Zeiss, of Jena. An apparatus of this kind is set up in Langenbeck House in Berlin and is owned by the Berlin Medical Society and used at their meetings.

7. Special Apparatus for Photographic Enlargements.

a) Apparatus for enlargements in dark-rooms. Fig. 5. The parts included between the luminants and the objective are encased to prevent diffusion of light. The magnification can be varied within wide limits (from 1 to 30) by shifting the screen, the objective or the luminant with respect to the condenser and the lantern slide.
b) Apparatus for enlarging in lighted rooms. All parts contained between the luminant and the screen are guarded from extraneous light.

These enlarging cameras can be used with any form of luminant:—1. Petroleum lamp; 2. Welsbach lamp; 3. zirconium burner; 4. lime-light burner; 5. electric arc-lamp. Lamps 3 to 5 necessitate the use of sheet metal cameras.

5. Carl Zeiss, Optical Works, Jena.

(See also Sections II, Vb, Vc, Ve and Vf.)

Appliances for Projection and Photo-micrography.

The firm of Carl Zeiss has, during the last fifteen years, bestowed unremitting attention upon the construction of appliances for photo-micrography and projection. Manufacture was originally confined to photo-micrographic appliances, which by slight modifications were rendered available for the projection of microscopic objects.

The increasing demand for simple appliances for the projection of large transparent objects, lantern-slides, &c., for the purposes of class demonstration led to the combination of the two forms of the apparatus into one so as to render it immediately available for macro-projection on the screen after removing the microscope.

This apparatus was made in various forms and sizes, and was primarily intended for illumination by transmitted light only. Subsequently there arose a growing demand for an efficient projection apparatus for opaque objects by incident light, which in recent years has been satisfied by the use of reflectors instead of the usual electric lamp. Opaque objects, of as much as 22 cm diameter, can now be projected upon screens several metres away without inconvenient loss of light. Recently the above apparatus has been rendered truly universal, i. e., it is adapted for the projection and photography of microscopic objects and for the projection by incident or transmitted light of large objects, by the application of episcopic illumination.

1. **Photo-micrographic Apparatus**, available both for micro- and macro-projection and for episcopic projection.

2. **Macro-projection Apparatus** for transmitted light, largest size, available for plates 13×18 cm.

3. **Epidiascope** with arrangement for micro-projection.

4. **Martens's Microscope** for photographing and projecting metallic specimens, &c.

Descriptions and price-lists in German, French and English may be had free on application.

e. Photographic Objectives.

1. C. P. Goerz, Friedenau near Berlin.

Optical Works.

Branches in New York, Paris, London. (Paris: 22 rue de l'Entrepôt.)

Maker of Photographic Apparatus.

Speciality: Photographic Objectives.

(See also Section Vf.)

1. **A Series of Goerz's Double Anastigmats** (Nos. 1 to 28). Fig. 1 and 2. German patent No. 74,437. These lenses gained the Prussian State Gold Medal, 1896.

   a) Series III, F: 7.7 (Nos. 1 to 15). Rapid Universal Objective for portraits, groups, instantaneous photographs of extreme rapidity, landscapes, architecture and interiors, also for enlargements.

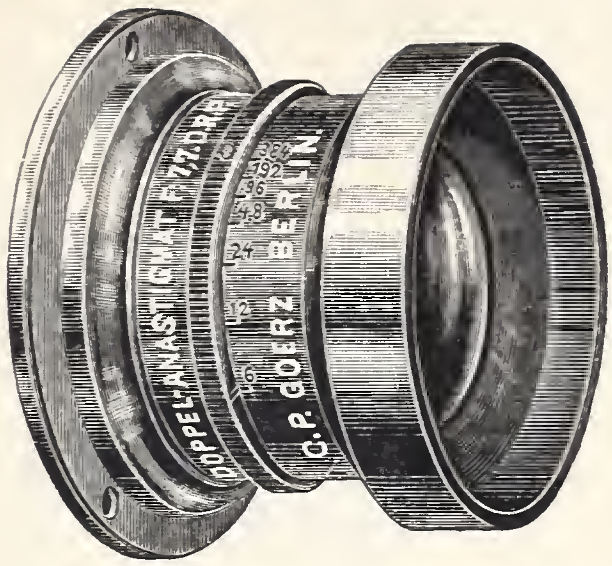


Fig. 1.

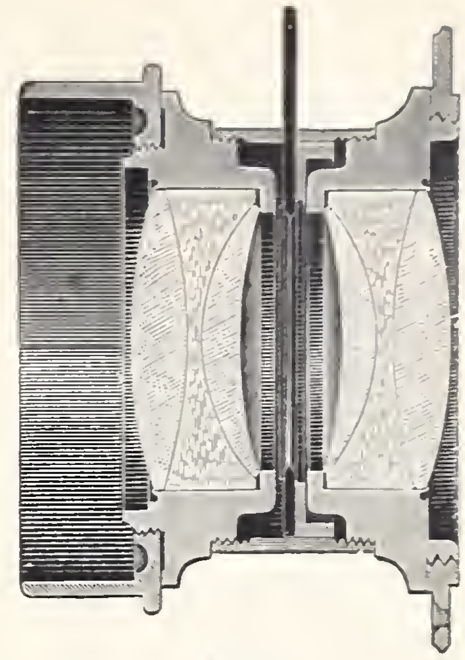


Fig. 2.

German patent No. 74,437.

The objectives of this series are universal lenses in a very wide sense. Their full aperture furnishes sufficient light for the requirements of instantaneous photography of extreme rapidity even in dull weather, and at the same time covers a plate area of 70° with sharp definition up to the margin. Wide-angle photographs embracing an angle of 90° can without difficulty be taken with these same lenses appropriately stopped down. The Double Anastigmats of Series III satisfy therefore the highest requirements both outdoors and in the studio, and are available for any mode of application.

b) Series III, F: 7.7 (Nos. 16 to 22) in special mounts for hand-cameras.

c) Series IV, F: 11 (Nos. 23 to 28). Rapid Copying Lens. The Double Anastigmat F: 11 is primarily designed for full size reproductions, and so applied covers a plate having a length equal to double the focus with uniform sharpness up to the edge, without curvature and astigmatism.

d) **Goerz's New Double Anastigmat** (Nos. 50 to 60) Series II. Rapidity F: 5. New formula consisting of two symmetrical halves each of which is composed of two cemented and a single lens. This objective yields a perfectly flat field without astigmatism and embracing an angle which is not equalled by any other lens of similar rapidity. The cemented lens constitutes a very good single landscape lens.

2. **A Series** (Nos. 29 to 34) of **Goerz-Anschütz's Cameras** (German patent No. 49,919) for various plate-sizes ($6\frac{1}{2} \times 9$, 9×12, 13×18 cm and stereoscope size) as well as English plate-sizes.

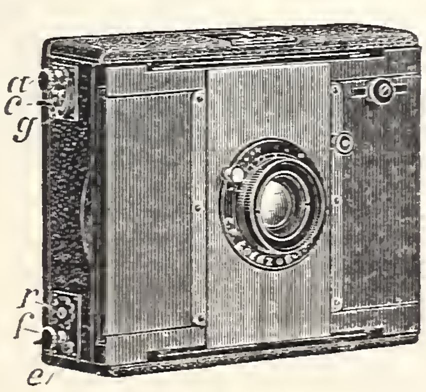


Fig. 3.

Goerz-Anschütz's camera, closed.

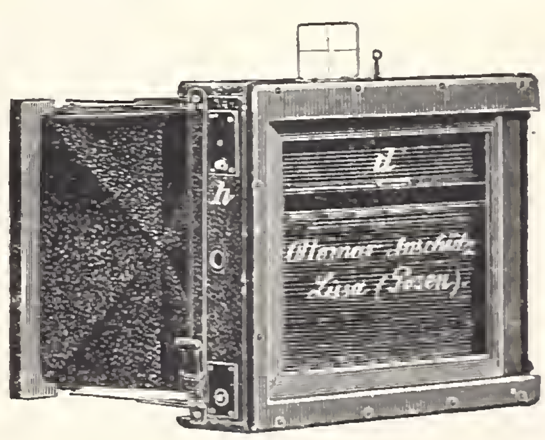


Fig. 4.

Goerz-Anschütz's camera, opened, view from the back.

This hand-camera is extremely compact and completely equipped, and is available for exposures down to $^1/_{1000}$ second. Fig. 3 and 4.

Detailed description, illustrated by many interesting instantaneous photographs, may be had free on application.

3. **Goerz's Photo-Stereo-binocular** (No. 35), German patent No. 101,609, being a combination of
   a) an opera-glass magnifying $2^1/_2$ times,
   b) a field glass magnifying $3^1/_2$ times,
   c) a photographic camera for single and stereoscopic time and instantaneous photographs on plates $4^1/_2 \times 5$ cm.

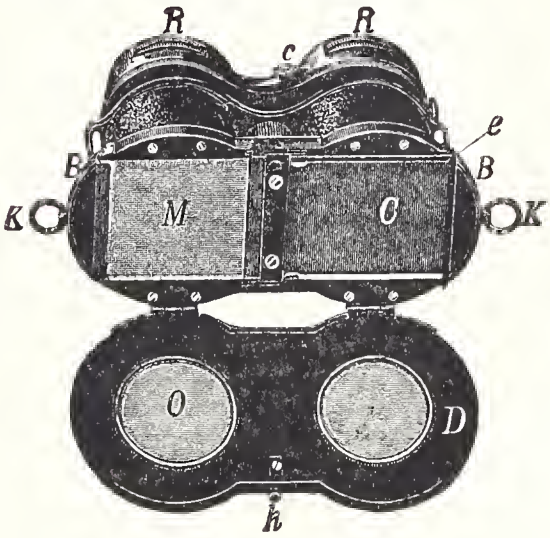


Fig. 5.

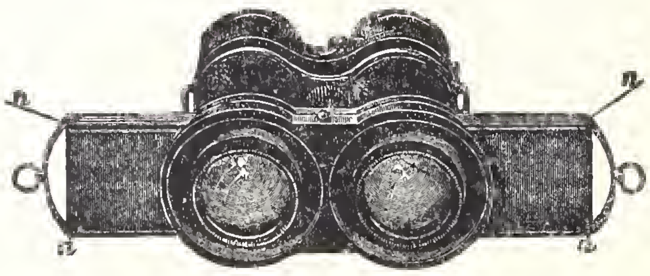


Fig. 6.

The necessary changes are made instantly and without unscrewing or detaching any portion of the apparatus. Fig. 5 and 6.

4. **Photographic Travelling Apparatus** (No. 36). **Various Changing Dark-slides** (Nos. 37 to 40). **Hand Enlarging Apparatus** (No. 41). **Various Sectorial Shutters** (Nos. 42 to 45). **Prisms with Objectives** (Nos. 46 and 47). **Light-filters** (Nos. 48 and 49).

2. C. A. Steinheil Söhne, Munich, 7 Theresienhöhe.

Optical and Astronomical Works. Established 1855.

Proprietor: Dr. Rudolf Steinheil.

(See also Sections II, Vb and Vf.)

Orthostigmatic Lenses.

German patent No. 88,505.—French patent No. 241,903.—British patent No. 12,949.

Rapid universal objectives possessing spherical, chromatic and astigmatic corrections of a high degree. These objectives include six lenses forming two symmetrical halves, each of which consists of a positive meniscus b enclosed between a biconvex lens a and a biconcave lens c, either having a higher refractive index than b. The sharp image embraces an angle of 80 to 85°.

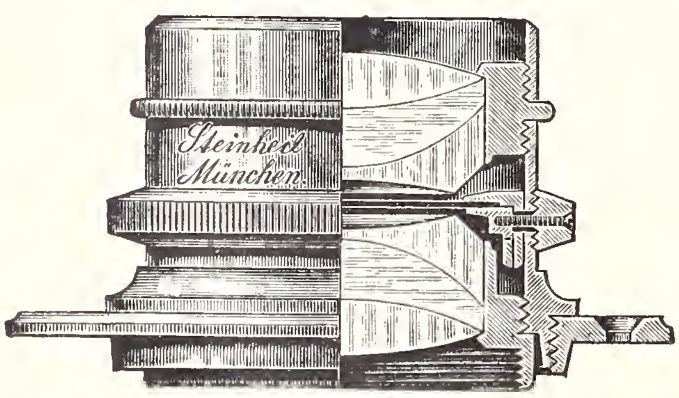


Fig. 1.

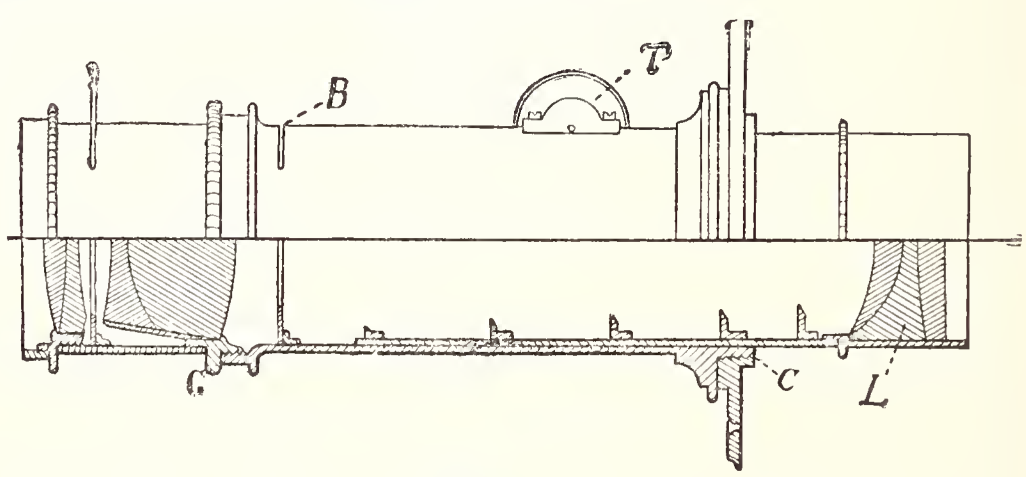


Fig. 2.

Three series: 1:6.8 (Fig. 1), forming excellent universal objectives, adapted for all branches of photography; 1:8 embracing only the smaller sizes and particularly adapted for hand-cameras, owing to the thinness of the lenses and the compact form of the objectives; 1:10 comprising large lenses of 30 cm focus and upwards only, specially adapted for all branches of modern process work.

Exhibits:

1. **Orthostigmatic Lens** 1:6.8 fitted with iris-diaphragm and new universal shutter Bb between the lenses.

2. **Orthostigmatic Lens** 1:10 with accessories for process work, viz. Prism with revolving collar and plano-parallel Light-filter fitting the lens and prism. Screen stops for autotype work.

Tele-photographic Objectives,

consisting of an ordinary photographic lens having a rapidity of about f/7 in conjunction with a negative magnifying lens (Fig. 2).

The position of the negative element with respect to the positive lens can be varied by means of a rack and pinion movement. This instrument furnishes any number of foci without moving its position. The camera extension is considerably less than that necessitated by a photographic objective having the required focus and used without a negative lens.

Exhibit:

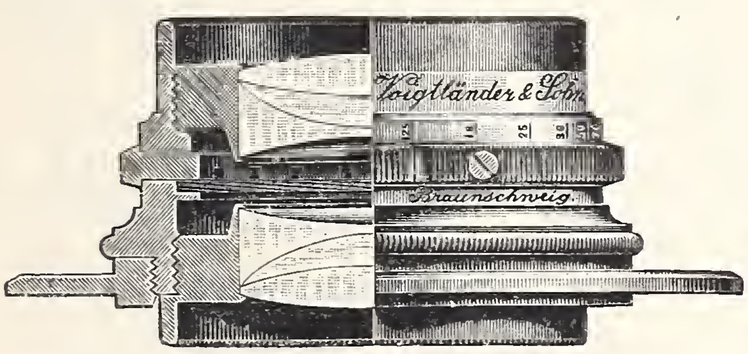
3. **Group Antiplanet** with magnifying lens, both forming a tele-photographic lens.

3. Voigtländer & Sohn, Limited.

Brunswick.

(See also Section Vf.)

Photographic Objectives.



Portrait Anastigmatic Lenses F:4.5.
Portrait Lenses F:2.4 to F:3.16.
Portrait Euryscopes F:4.5.
Collinear Lenses F:5.4 to F:6.3.
Collinear Lenses F:7.7.
Collinear Lenses F:12.5.
Triple Anastigmatic Lenses F:6.8 to F:7.7.
Reversing Prisms, Plane Mirrors, &c.

4. Paul Waechter, Berlin-Friedenau.

Optical and Mechanical Works.

Established 1872.

(See also Section Vc.)

1.	**Leucograph**,	Ser. IIIa	No. 1,	125 mm focus,	with wheel-diaphragms.
2.	-	-	No. 1a,	150 -	- - iris-diaphragm.
3.	-	-	No. 2,	210 -	- -

4. Leucograph, Ser. IIIa No. 3, 250 mm focus, with iris-diaphragm.
5. - - No. 4, 340 - - - -
6. - - No. 5, 420 - - - -
7. - - No. 6, 540 - - - -
8. - - No. 7, 650 - - - -
9. - - No. 1 } in detective mount with helical focussing arrangement and iris-diaphragm.
10. - - No. 1a }
11. - - No. 2 }

12. A Pair of Leucographs, Ser. IIIa No. 1, mounted together on an aluminium plate, for stereoscopic views, with joint focussing arrangement and iris-diaphragm.

13. Set of Anastigmatic Convertible Lenses for 13×18 cm plates.

Various Folding Cameras, Kodaks fitted with Lenses, various Detective Mounts, Iris-diaphragms, &c.

5. Carl Zeiss, Optical Works, Jena.

(See also Sections II, Vb, Vc, Vd and Vf.)

I. Photographic Objectives for General Use.

The firm of Carl Zeiss took up the manufacture of photographic lenses some twelve years ago. At that time there were three types dominating the market, viz. the Petzval portrait lens, the aplanatic lenses and single landscape lenses with front stops. Next to these should be mentioned the slower type of Steinheil's antiplanets, the so-called group-antiplanets.

All these lenses were made either entirely from the old glasses or from the new Jena glasses introduced in 1886, mainly on account of their improved durability and transparency. But all these lenses had one defect in common. Whenever the angle of vision exceeded 30° the older types gave evidence of either astigmatic aberration in a more or less marked degree, which was invariably the case when they were corrected spherically, or they were insufficiently corrected spherically, if, as rarely happened, they were corrected anastigmatically for any considerable area. This latter class of lenses comprised the only objective which required, for the realization of its formula, the new Jena glasses as essentially optical constituents, viz. H. Schroeder's concentric lens, which originated at that time.

Dissymmetrical Anastigmatic Doublets.

The improvements in photographic lenses initiated by Dr. P. Rudolph and patented by the firm of Carl Zeiss in 1890 consisted in the opposite relations of the refractive indices in the two members of a photographic doublet, whereby Dr. Rudolph had enunciated a new principle which provided for the simultaneous correction of the spherical aberrations and the anastigmatic aplanization of the field.

This essentially dissymmetrical formula has subsequently been embodied in numerous series of widely differing aperture and showing a gradually developing approach to a perfectly corrected photographic objective.

The rapid lenses of this type, owing to their anastigmatic correction and great covering power, are available as wide-angle lenses.

The same type was also developed into a true wide-angle lens and was made to embrace angles exceeding 110°.

Development of the Combination-lenses.

Within a year after enunciating the anastigmatic principle, Dr. P. Rudolph applied it to the improvement of the landscape lens, treated as an element of the combination.

These sets consisted, previous to the introduction of the anastigmatic principle, almost exclusively of aplanatic halves and emanated principally from France. This form of binary combination was, however, ill adapted for the spherical correction in oblique pencils, whilst the anastigmatic correction was no better than that existing in the old doublets.

The application of the anastigmatic principle considerably modified these defects. The single lens of Series VI, computed in 1891 and placed upon the market in 1893, was in a more or less marked degree free from astigmatism as well as distortion. General correction was carried a step further in the formula of the single lenses of Series VII, which were brought out in 1894. These landscape lenses consist of four cemented lenses and are corrected spherically, chromatically and astigmatically in such a manner as to be available for combination into sets satisfying the highest requirements.

The Planar.

The anastigmatic formula, though completely successful in its applicability to universal and wide-angle lenses, did not satisfy the very highest requirements of the finest process work. It failed in this respect for the same reason which had excluded the old symmetrical lenses from progress in this direction, inasmuch as the correction of spherical aberrations was not satisfactorily free from zones.

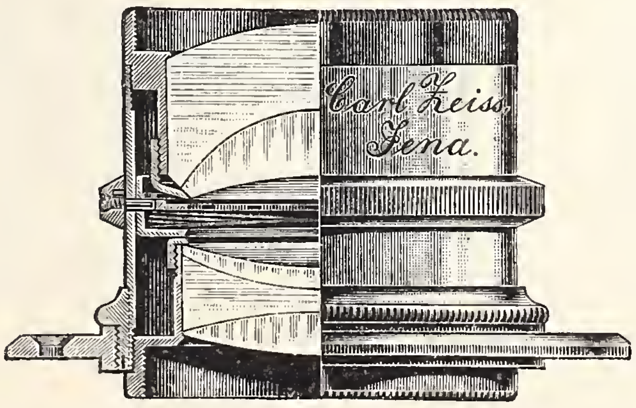
To fill this gap Dr. Rudolph made a series of computations which, in 1896, culminated in the Zeiss Planar, a type which is almost entirely free from zones and, at the same time, shows a remarkably close approach to perfect applanation. It was, however, not possible to cement all the lenses in either component. This is the first instance of modern objectives of German origin showing light reflecting surfaces.

These three principal types, as specified above, represent the creative achievements of the firm. In addition, we may refer to the manufacture, since 1893, of tele-photographic objectives, consisting of positive and negative components, a combination which had been originated in 1851 by I. Porro, of Paris, and twenty years later taken up with energy by Th. R. Dallmeyer, of London.

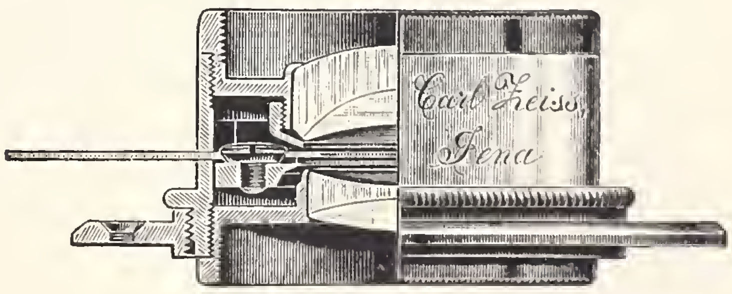
Finally, we may mention the independent re-discovery of the anamorphotic formula of 1897, the first and practically most important part of which was, however, subsequently found to have been patented by the French optician Léon Farrenc in 1862.

Anastigmatic Doublets.

Series IIa, 1:8. Objectives for instantaneous exposures out of doors, also for portraits, groups, landscapes and for copying. Originated in 1893. 9 foci from 90 to 433 mm.



Type of the rapid doublets.
Series IIa. 5 lenses.

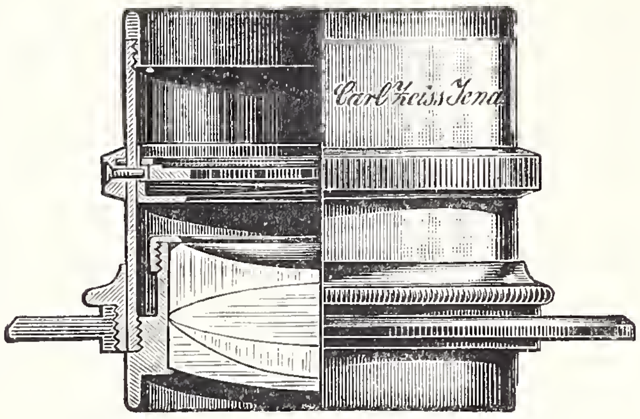


Type of the slower doublets.
Series IIIa and V. 4 lenses.

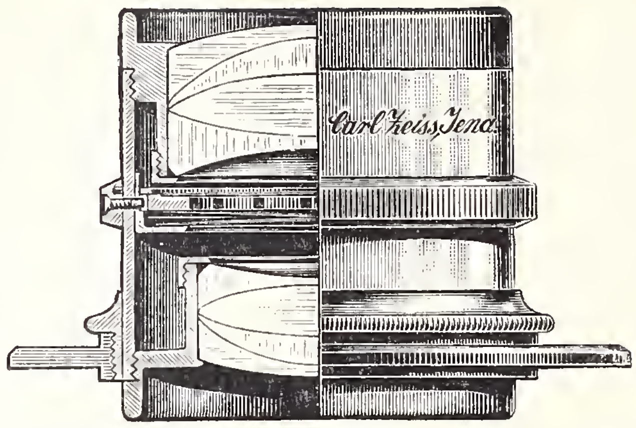
Series IIIa, 1:9. Universal and group lenses, also adapted for large portraits, interiors and copying. Originated in 1891. 14 foci from 75 to 820 mm.

Series V, 1:18. Wide-angle lenses for architecture, interiors and photogrammetric work. Originated in 1890. 10 foci from 40 to 390 mm.

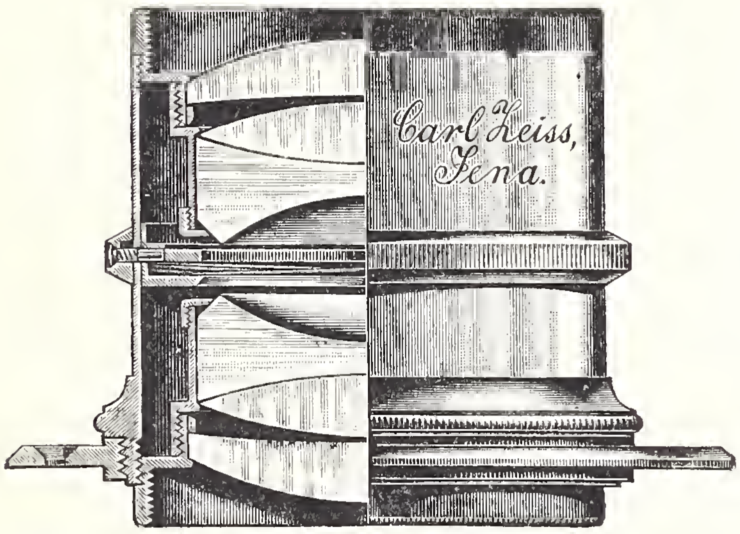
Convertible Anastigmats.



Quarternary convertible Anastigmat.



Hemisymmetrical combination anastigmat, furnishing 3 foci.



Type of the planar.

Series VII, 1:11 and 1:12.5. Rapid single lenses for instantaneous photography and landscapes. Convertible element for anastigmatic sets. Originated in 1895. 14 foci from 100 to 1000 mm.

Series VII a, 1:6.3, 1:7.0, 1:7.7. Rapid objectives for wide-angle instantaneous photographs, portraits and groups, also for architecture, landscapes and photogrammetric photography. These objectives are composed of two lenses of the preceding group. 27 foci from 61 to 595 mm.

Series I a. The Planar. 1:3.6 to 1:5. Rapid special objectives for enlarging and projecting, also for instantaneous photography, portraits and groups. Originated in 1897. 18 foci from 20 to 610 mm.

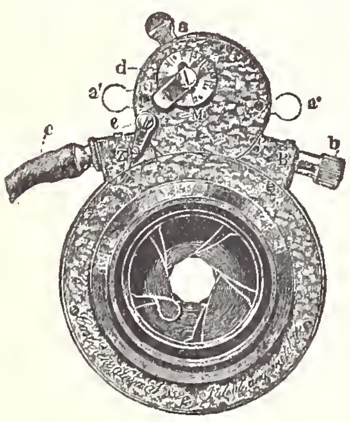
Tele-photographic Objectives. Two types are made, one being a rapid objective for portraits and landscapes, the other a slower wide-angle lens for architectural details. The tube is fitted with an automatic iris-shutter, and is graduated in terms of the optical intervals.

The Anamorphotic System, for the production of definite distortions, the ratios of distortions varying from 10:9 to 10:3.

II. Objectives and Auxiliary Appliances for Process Work.

The construction of copying lenses has, from the first, been regarded as a difficult department owing to the accentuated requirements as to precision and workmanship imposed by their peculiar mode of application and their large size.

The principal series of Dr. Rudolph's formula have been specialized so as to render them available for copying etchings and mezzotints. Among these copying lenses will be found representatives of the anastigmatic doublets, the convertible anastigmats and the planars. The latter being free from zones have served to realize an idea proposed by E. Deville, and thus to limit in the autotype process, by means of symmetrically perforated stops—so-called coincident stops—, the loss of light resulting from the form of the screen.



Adjustable iris-shutter.

As adjunct's for copying lenses we make reversing prisms with silvered hypotenusal faces, the use of which dates back to Ch. Chevalier, and also strictly plane and parallel light-filter troughs.

III. Shutters.

The three forms of shutters manufactured by us are made to work in the plane of the stop; the iris, which opens from the centre, serving both as a shutter and lens-stop proper. This arrangement ensures the most favourable conditions as to distribution of light obtainable with lens-shutters.

Descriptions and price-lists in French, German and English may be had free on application.

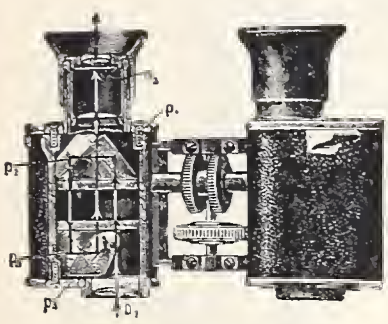
f. Hand-telescopes and Terrestrial Telescopes.

1. C. P. Goerz, Friedenau near Berlin.

Optical Works.

Branches in New York, Paris, London. (Paris: 22 rue de l'Entrepôt.)

(See also Section Ve.)



Goerz's Trihedron Binoculars (Nos. 61a to h). German patent No. 104,343.

Kepplerian Telescopes with erecting prisms, embracing a field of 40° fitted with patent objectives yielding images of exquisite definition, clearness and absence of colour. Magnifying powers: 3, 6, 9 and 12 diameters.

The field of view of these glasses (40° absolute) is not surpassed by any other glass.

Detailed catalogues of C. P. Goerz's objects of manufacture may be had free on application at the Exhibition.

2. M. Hensoldt & Söhne, Wetzlar.

Optical Works.

Fig. 1.

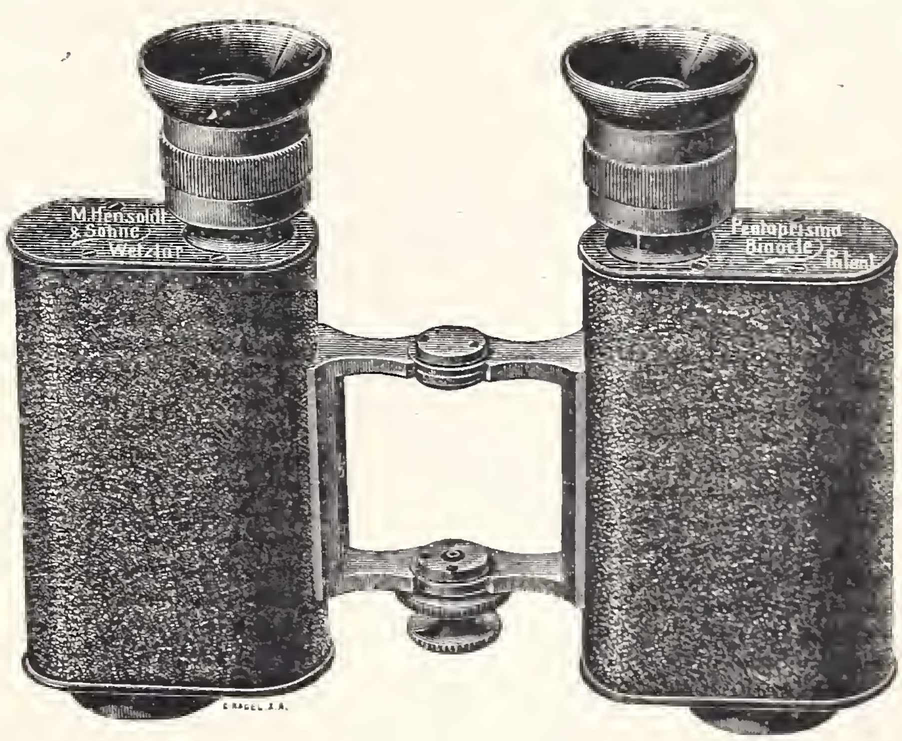


Fig. 3.

1. **Stereo-binocular,** a field-glass of convenient and pleasing form and possessing considerable light-gathering power, fitted with orthoscopic eyepieces of the terrestrial type and a patented form of short focus objectives, which eliminate the necessity of separately focussing near and distant objects. These glasses are particularly adapted for military, marine, sporting and travelling purposes. They magnify 7 diameters. Figs. 1 and 2.

2. **Optical Surveying Pentagon** for rapidly and accurately measuring and setting off angles of 90 and 180°.

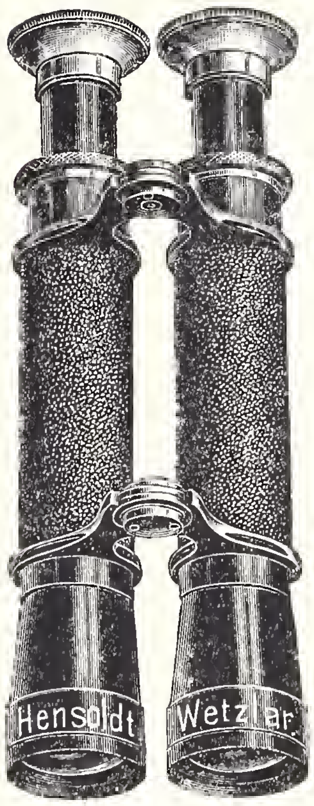


Fig. 2.

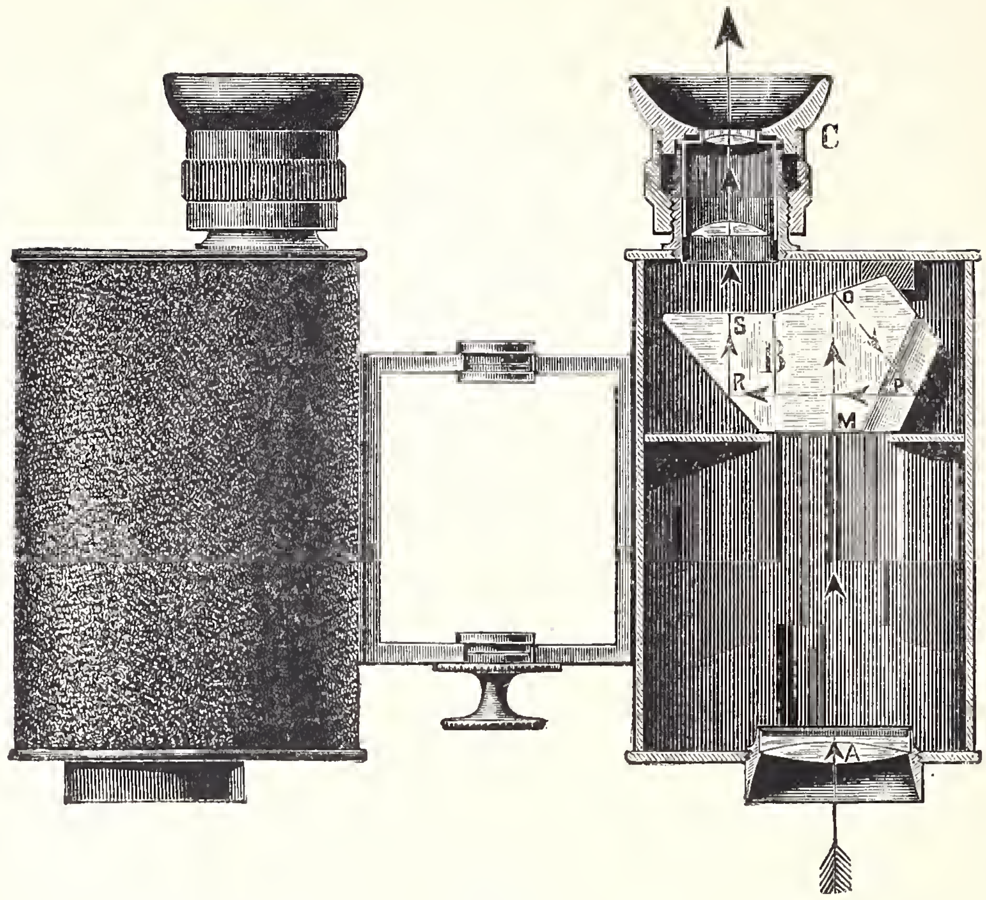
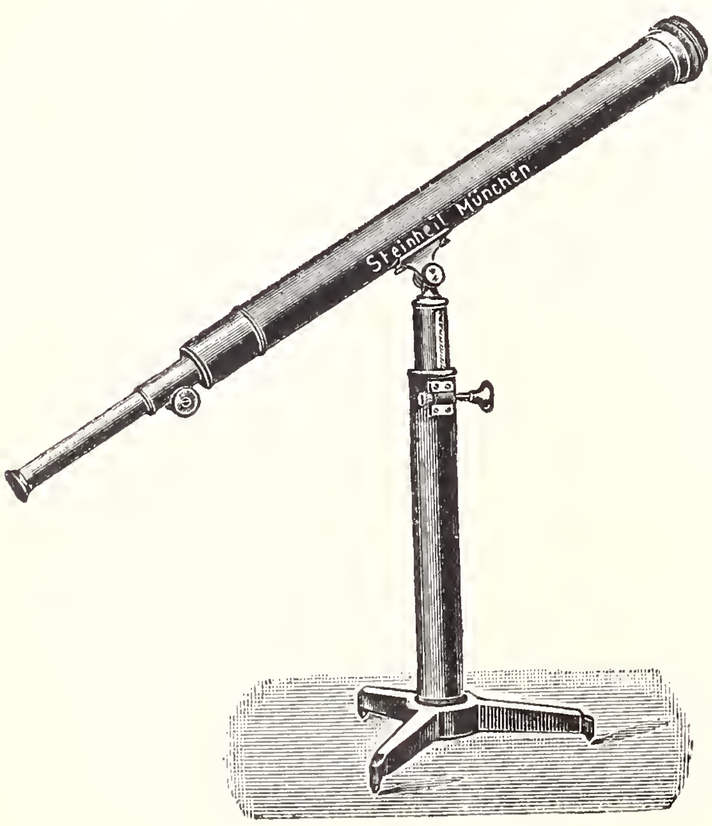


Fig. 4.

3. **Pentaprism Binocular.** Figs. 3 and 4. An entirely new construction, patented in many countries. The optical part consists of a binary objective of great light-gathering power and a short astronomical eyepiece, between which is placed a prismatic combination. The whole of the optical parts is made of the purest and best glasses, accurately ground and polished. The tubes are adjustable to suit the distance between the user's eyes. The eyepiece can be adjusted so as to fully utilize the visual power of each eye. No re-adjustment is required after once adjusting the distance between the tubes and focussing the eyepieces for sufficiently distant objects.

The pentaprism binocular magnifies 7 times and the objective has an aperture of about 24 mm. The linear field of view embraces 97 per 1000 m. Its weight is 395 g.

4. **Optical Parts for Scientific Instruments.** Telescope objectives, terrestrial and astronomical eyepieces of an original type, prisms, &c.



3. C. A. Steinheil Söhne,

Munich, 7 Theresienhöhe.

Optical and Astronomical Works. Established 1855.

Proprietor: Dr. Rudolf Steinheil.

(See also Sections II, Vb and Ve.)

Hand-telescopes and Terrestrial Telescopes.

1. Draw-telescopes:—

a) Of considerable magnifying power, fitted with a double objective and ordinary terrestrial eyepiece BD.

Exhibits: Draw-telescope with tree-screw, mounted on folding tripod stand of wood. (The tree-screw is available for use with and without the stand.) Draw-telescope mounted in bronzed brass and fitted with a sun-shade. Suitable for deer-stalking.

b) Of considerable light-gathering power (night-telescopes), fitted with triple objective and achromatic terrestrial eyepieces BF.

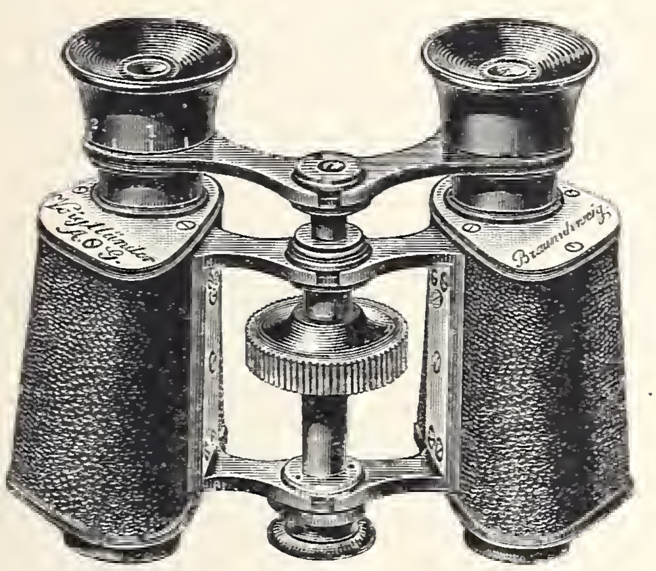
Exhibit: Draw-telescope with a small folding table-stand.

Terrestrial Telescope with Stand, as shown in the illustration, fitted with a double objective and ordinary terrestrial eyepiece BD. The telescope body is cased in mahogany. Focussing is facilitated by a rack and pinion movement. The stand consists of an iron table tripod and a brass column, and the telescope is directed by hand horizontally and vertically, the column being adjustable in height and provided with a clamp.

4. Voigtländer & Sohn.

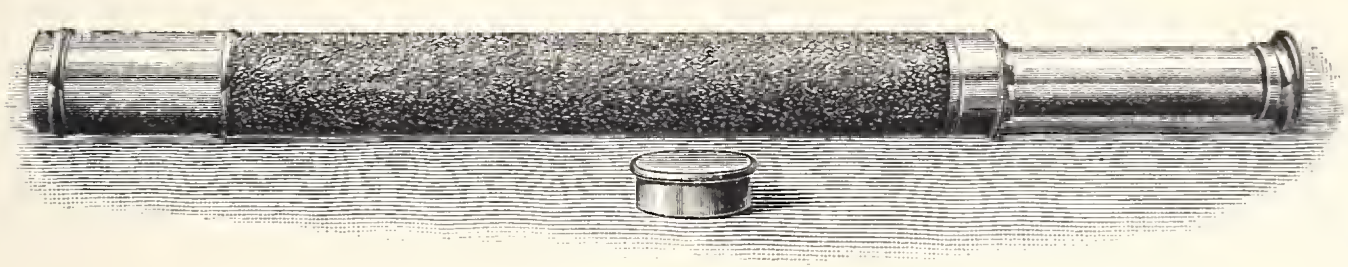
Limited.—Brunswick.

(See also Section Ve.)



Telescopes.

Galilean Binoculars, Field, Race and Opera Glasses.
Night Marine Glasses (as supplied to the German Navy).
Terrestrial Binoculars with variable powers (Biese's system).
Prism-binoculars.
Marine Telescopes.
Draw-telescopes for tourists.
Stand-telescopes, aperture up to 4″.
Rifle Telescopes of highest light-gathering power.



5. Carl Zeiss, Optical Works, Jena.

(See also Sections II, Vb, Vc, Vd and Ve.)

Terrestrial Telescopes.

The manufacture of terrestrial telescopes was taken up by the firm in 1894, when the principle of Porro's erecting prisms was applied to the construction of a new form of terrestrial telescope.

Porro's discovery dates from the middle of this century, but it subsequently sank into oblivion. By its means an astronomical telescope can be made to yield erect images and is thereby converted into a terrestrial telescope. A hand-telescope constructed on this plan is not subject to the objectionable features of the Galilean telescope, and at the same time the shortening of the tube-length has the effect of reducing in an extraordinary degree the usual dimensions of the instrument. Besides taking full advantage of the optical resources of this prism combination in the construction of superior terres-

trial telescopes, the firm has further developed the possibilities resulting from the application of Porro's prisms in the construction of new binoculars, by increasing the normal inter-ocular distance of the objectives and thereby gaining, after the tele-stereoscopic principle of Herschel and Helmholtz, an increase in the power of appreciating differences of distance and an enhanced stereoscopic effect. Binocular telescopes constructed on this principle render differences of depth in space apparent at a given magnification with a degree of distinctness which is only attainable in an ordinary binocular of considerably greater magnifying power and therefore having a much smaller field of view.

This tele-stereoscopic principle has been embodied in all Zeiss binoculars. The so-called "Field-glasses" emulate the form of the ordinary binocular and increase the stereoscopic effect of natural binocular vision in the proportion of $1^3/_4:1$ to $2:1$. In the case of stereo hand-telescopes, the objectives are respectively 5 times and $6^1/_2$ times further apart than the eyes, and in the stand binoculars this ratio is 9 and even 32. The binocular telescopes belonging to this latter category show very distant objects in solid outlines and in their true relative position one behind the other.

The tele-stereoscopic principle has further been embodied in the construction of the so-called stereo-telemeter as exhibited by this firm among the optical measuring instruments. See section Vb.

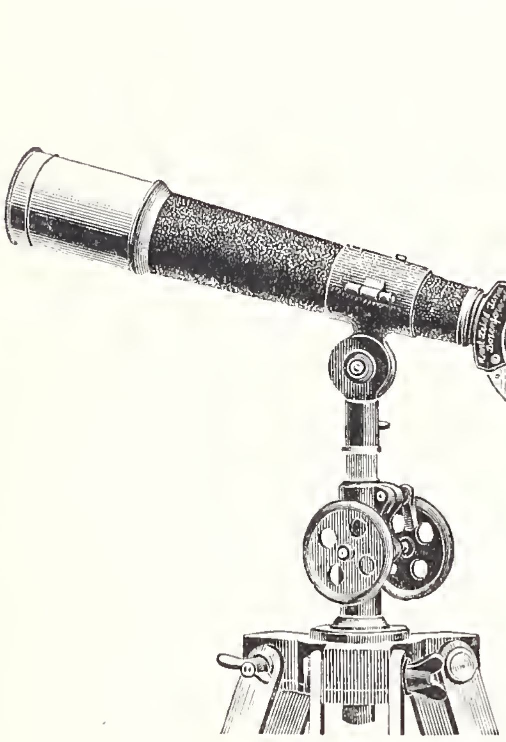


Fig. 1.
Revolver telescope, magnifying 12, 25 and 40 times.

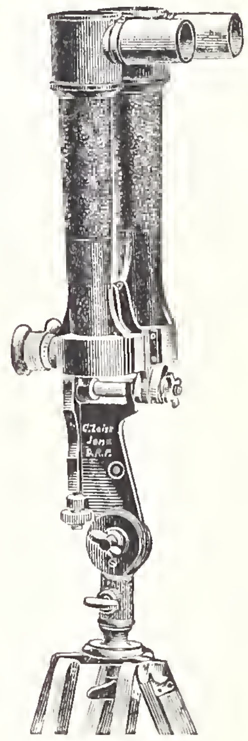


Fig. 2.
Hinged stereo stand-telescope showing the telescopes folded upwards, magnifying 15 times.

I. Stand-telescopes.

A. Monocular Stand-telescopes

(Revolver telescopes, Fig. 1) fitted with Amici-Abbe erecting prisms and furnishing three magnifying powers (by means of three eyepieces mounted on a revolving collar). The telescope is held by a metal frame mounted on a wooden stand. There are two models magnifying 12, 18, 24 and 12, 25, 40 times respectively.

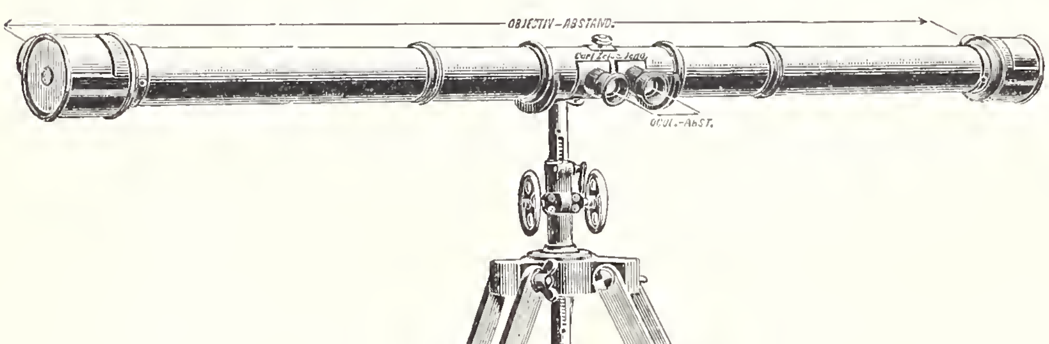


Fig. 3.
Horizontal beam stand-telescope, magnifying 20 times.

B. Binocular Stand-telescopes,

having their objectives at a considerable distance apart, supported by a metal frame mounted on a wooden stand.

a) With Porro's erecting prisms and hinged at the centre (Hinged Stereo Stand-telescope, Fig. 2). Two models both having an intra-objective distance of 570 mm, one magnifying 15, the other 10 and 18 times by two pairs of eyepieces mounted on revolvers.
b) Rigid Horizontal "Beam" Stand-telescope fitted with terrestrial eyepieces, with objectives 2000 mm apart and magnifying 20 times (Fig. 3).

A detailed description of the telescopes specified under I, A and B, will be found in our Catalogue of "New binocular and monocular Stand-telescopes," which may be had free on application in either French, English or German.

II. Hand-telescopes.

A. Monoculars fitted with Porro's erecting prisms.

1. Yielding one magnifying power. Seven sizes magnifying respectively from 4 to 12 times.
2. Yielding two magnifying powers, 5 and 10, and fitted for this purpose with two eyepieces mounted on revolvers.

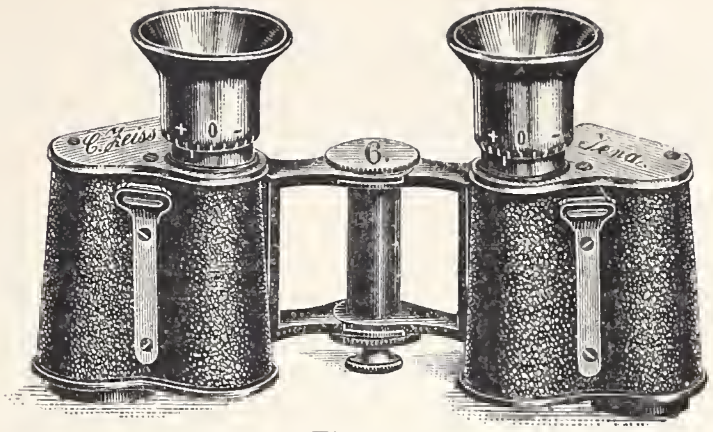


Fig. 4.
Field-glass, magnifying 6 times.

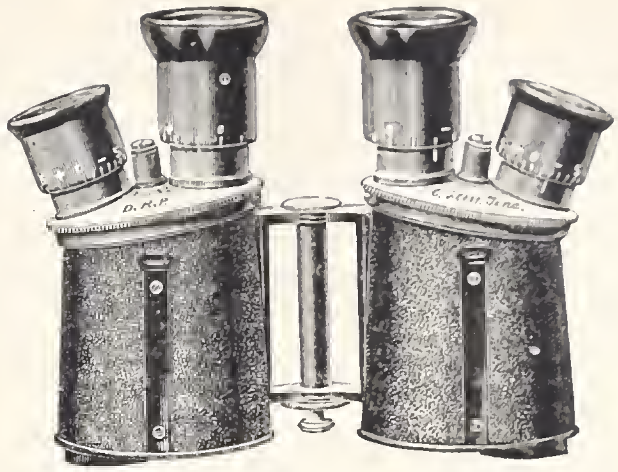


Fig. 5.
Day and night marine binocular, magnifying 5 and 10 times.

B. Binoculars with increased intra-objective distance and fitted with Porro's erecting prisms.

a) Field-glasses (Fig. 4).

1. Yielding one magnification only. Seven sizes having their objectives from 115 to 130 mm apart and magnifying 4 to 12 times respectively. Their light-transmitting power varies according to the purpose for which they are designed.
2. Yielding two magnifications, 5 and 10, being fitted with two pairs of eyepieces mounted on revolvers, known as "Day and Night Marine Binoculars" (Fig. 5). The distance between the objectives is 130 mm.

b) Stereo-telescopes (Fig. 6). Two sizes having intra-objective distances of 340 and 430 mm and magnifying 8 and 10 times respectively.

A detailed description of the telescopes specified under II, A and B, will be found in our Catalogue of "Portable Zeiss Binoculars and Stand-telescopes," which may be had free on application in either French, English or German.

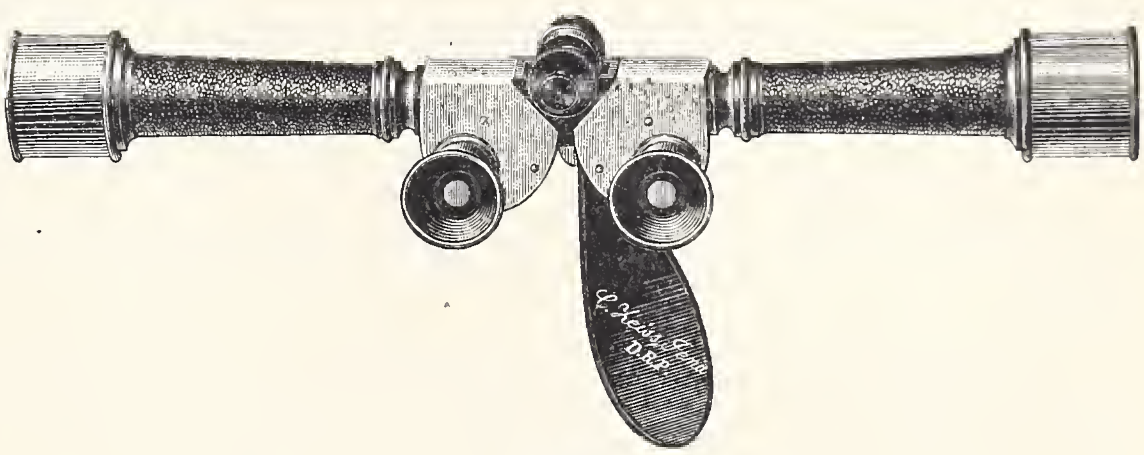


Fig. 6.
Portable stereo-telescope. Shown with outstretched arms. Magnifying 8 times.

g. Crystalloptics, Appliances for Demonstrating and Observing the Phenomena of Light.

1. R. Brunnée (late Voigt & Hochgesang), Göttingen.

Maker of Crystalloptical Instruments and Preparer of Microscopic Lamina of Rocks, Minerals, Fossils, &c.

(See also Section I.)

1. Large Microscope No. 1A, as designed by Prof. C. Klein, for mineralogical and petrological research. This instrument satisfies in every respect the most advanced requirements and is specially adapted for fine measurements in parallel polarized and in convergent light. The circle is made of nickelin, divided into $^1/_2$ degrees and reads by a vernier to 1'. The Bertrand lens is

adjustable by a rack and pinion movement with respect to the objective and eyepiece so as to render the interferential curves sharply adjustable with any objective and eyepiece. The light can be stopped down by means of an iris-diaphragm for the better examination of small mineral laminae. The polarizer is provided with an arrangement for quickly passing from parallel polarized to convergent light, and another polarizer with large Nicol prism and a set of lenses is supplied with the microscope for very convergent light.

The preparations can be searched and measured systematically with the aid of a covered compound prismatic movement (D.R.G.M. No. 69,865), which nowhere obstructs or darkens the graduations on the circle, whilst the prisms themselves, being thoroughly protected from dust and injury, are not apt to get out of order.

The equipment of the microscope includes objectives Nos. 9, 8, 7, 4, 2, 1, 00, an objective of 1.52 numer. aperture, eyepieces Nos. 1, 2, 3, 4, Bertrand eyepieces, compensating eyepiece, screw micrometer eyepiece, quartz wedges of the I. to III. order, penumbra polarizer, quartz selenite and mica films, and a Universal Rotator combining the features of Klein's and Fedorow's designs.

2. **Microscope No. 3A.** This is a simple instrument which suffices for all ordinary investigations in parallel polarized and convergent light. The circle is divided into 360° and reads by a vernier to $^1/_{10}$°. The polarizer is fitted with a rapid lens-changer. The tube is without a draw and contains a Bertrand lens and a movable and rotating Nicol prism. The microscope outfit includes objectives Nos. 7, 4, 2, eyepieces 2, 3, 4, a quartz wedge, selenite, quartz and mica films.

3. **Microscope of English Form,** own design. Both Nicol prisms are turned by tooth-wheels mounted in spring-bearings. The tooth-wheel is surmounted by a circle divided into 360°, reading to $^1/_{10}$° by a vernier. The draw-tube is fitted with a Bertrand lens and is adjustable by a rack and pinion movement. The condenser lenses are independent of the rotation of the Nicol prisms and can be raised and lowered by a screw. The stage is fitted with means for quickly changing the illumination. The mechanical stage can readily be detached. The optical equipment includes objectives Nos. 9, 7, 4 and 2, eyepieces 1, 2, 3 and 4, quartz wedge, selenite and mica films.

4. **Collection of 347 Laminated Sections of the Principal Types of Rocks,** selected according to H. Rosenbusch's Mikroskopische Physiographie der massigen Gesteine, 3rd edition.

This collection includes the principal groups of eruptive rocks and especially types identified during recent years. The preparation of these rocks is due to the kindness of Messrs. Brögger, Chelius, Diller, Hibsch, von Kraatz-Koschlau, Osann, Ramsay, Rosenbusch. Prof. Rosenbusch has moreover kindly compiled and verified the laminations.

5. **Collection of 115 Laminated Sections of Petrographically Important Minerals,** as compiled by Prof. C. Klein and prepared and cleft in such a manner as to clearly indicate the crystallographic form of the preparation.

6. **A Series of Large Laminations of Interesting Silicious Woods,** as prepared for Prof. Count zu Solms-Laubach.

7. **Chemical Microscope,** constructed according to the suggestions of Prof. O. Lehmann and available for observation at white heat and for electrolysis. Experiments at white heat are made with the aid of a double cased objective which is traversed by a continuous stream of cold water. The blow-pipe flame passes through an asbestos tube inserted into the opening of the microscope stage. The preparation is placed upon a small object-slide (10×10 mm) resting upon a separate object-stage, which is manipulated on the microscope stage like an ordinary object-slide. This small stage is fitted with four fine platinum points which support the small slide so as to conduct as little heat as possible to the loose stage.—Electrolytic experiments are likewise performed with the aid of a loose stage which slides upon the microscope stage like an ordinary slide. The electrolytic stage is fitted with two ebonite cups and platinum electrodes. The mercury cups are connected with two other fixed cups forming the terminals of a small battery. Polarization is effected by means of two mirrors, whereas the illuminating mirror can be rotated so as to rapidly change the illumination. The burner is attached to the horse-shoe foot and can be turned aside. The admission of gas and air is regulated by two screw-valves. Two blow-tubes can be attached to the stage so as to rapidly cool the objective or preparation. The optical equipment includes objectives No. 1, 4 and 5, eyepieces 2, 3 and 4, selenite and mica films.

2. R. Fuess, late J. G. Greiner jr. & Geissler,

Steglitz near Berlin, 7/8 Düntherstr.

Mechanical and Optical Works.

(See also Sections IIIa, IV, Vb and Vd.)

1. **Films and Preparations of Crystals.**

2. **Reflecting Goniometer, Model IVa.** Covered circle 10 cm in diameter divided into $1/2°$, reading to 1′ by 2 verniers, one eyepiece and Websky's slit. The centreing and adjusting appliances are capable of movement within wide limits. (C. Leiss, Die optischen Instrumente, &c., p. 127.)

3. **Reflecting Goniometer, Model II,** on tripod with levelling screws. The limb is covered and divided on silver into $1/4$ degrees. The alhidada reads to 30″ by 2 verniers. The telescope moves with the alhidada and can be clamped. The slit collimator is stationary. The instrument is equipped with 4 eyepieces and 4 signals. (C. Leiss, ibid., p. 119.)

4. **New Polarizing Apparatus,** with lens of wide aperture. (C. Leiss, ibid., p. 157.)

5. **Axionometer** with new telescope capable of transition, during observation, from reductions of 4 to magnifications of 4, as suggested by E. A. Wülfing (N. Jahrb. f. Mineralogie, Suppl. 1898. XII. p. 405).

6. **Large Microscope, Model VI,** with jointly moving Nicols, revolving and movable stage, throw-out tube and eyepiece Nicols, adjustable analyzing and polarizing Nicols, and objective changer. (C. Leiss, ibid., p. 199.)

7. **Microscope, Model IIIa,** with extra large field of view. (C. Leiss, ibid., p. 191.)

8. **New Rotating Gears of various kinds** suggested by Klein, von Fedorow and others. (C. Leiss, ibid., p. 231.)

9. **New Dichroscopes.** (C. Leiss, ibid., p. 179.)

3. Gustav Halle, Rixdorf near Berlin, 53 Hermannstr.

Maker of Scientific and Technical Instruments of Precision.

(See also Sections Vb, Vc and X.)

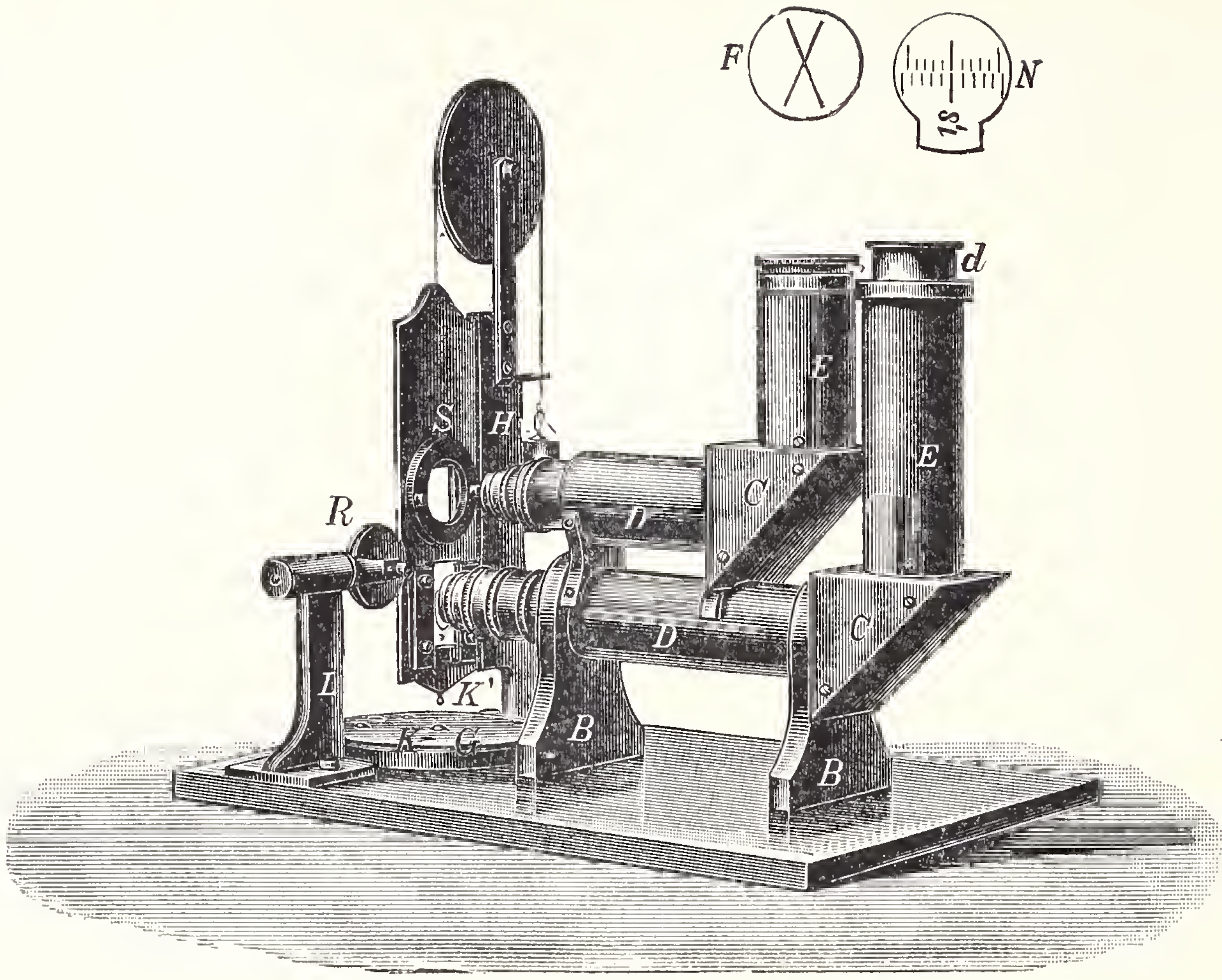
1. **Demonstration Hand-microscope for Petrological Purposes.** This instrument is partly made of aluminium in order to, as far as possible, reduce the weight and facilitate its transmission from hand to hand during lectures. The tube-analyzer can be drawn in and out and turned 90°. Between this analyzer and the objective, the tube is provided with a slit for the auxiliary mineral plates ($1/4$ phase mica and selenite films, Red I. order). The object-stage is made to revolve and is divided into single degrees, the polarizer slides up and down and may be turned 45°. In addition to objectives 0, 2 and 4, the microscope is supplied with a lens for axial images fitted with condenser, together with a corresponding lens in adjustable mount to rest on the eyepiece.

2. **Universal Hand Grinding Apparatus** for preparing accurately orientated laminae of crystals, fitted with transparent object-carrier and an accessory for small objects.

3. **Improved Dichroscope** (G. Halle and Cathrein's new form).

4. **Hand-apparatus for Demonstrating Double Refraction.**

5. **Thickness-micrometer,** as described in the Zeitschr. f. Instrumentenkunde, October 1896. See Fig. on p. 144. The values are read off directly in 0.001 mm by a powerful microscope with the aid of an ocular vernier and a transparent glass scale (0.01 mm) illuminated from the back. Without metal scale, without filar micrometer. (Registered.)



6. **Thickness-micrometer for Controlling Rectangular Prisms** (after Voigtländer-Halle). The values are read off to within 18 seconds of the arc by means of an ocular scale situated within the reading microscope. The illumination from the back furnishes a uniformly white field which shows in sharp contrast the intensely black lines of the scale as well as the extremely fine point of the gauging lever. (Registered.)

7. **Spheroscope, or Apparatus for Gauging Curves** after Voigtländer-Halle, for rapid comparison of lenses of any size or curvature. The reading microscope is fitted with an eyepiece scale, and by its means the radial differences can be accurately determined within 20 seconds of the arc. The oscillations of an extremely fine gauge index are shown with exquisite sharpness on a white field illuminated from the back. The instrument is supplied with four measuring rings at least, but any number of rings of special diameter can be adapted to the instrument. Their price varies with their size. (Registered.)

4. Valentin Linhoff, Munich, 42 Goethestr.

Philosophical Instrument Maker.

1. **Reflecting Goniometer with vertical divided circle.** The telescope is parallel to the plane of the divided circle and points to the axis of rotation. It is fitted with an adjustable centreing slide, and a definite point of the signal can be made to coincide with the centre of the cross-lines.

2. **Reflecting Goniometer with horizontal divided circle,** two telescopes, collimator with Websky's slit and two micrometer adjustments. The goniometer is mounted on a stout column so as to ensure absolutely unimpeded rotation of the circle and adjustability, in any position of the centreing stage.

These instruments are adapted for the same operations as Fuess's goniometers. Although, naturally, second to the latter in point of exactness, yet, by reason of their simplicity, they are adapted for convenient and accurate working. (See Groth's Physikalische Krystalloptik, 1895, pp. 626 and 648.)

5. Wilhelm Siedentopf, Würzburg.

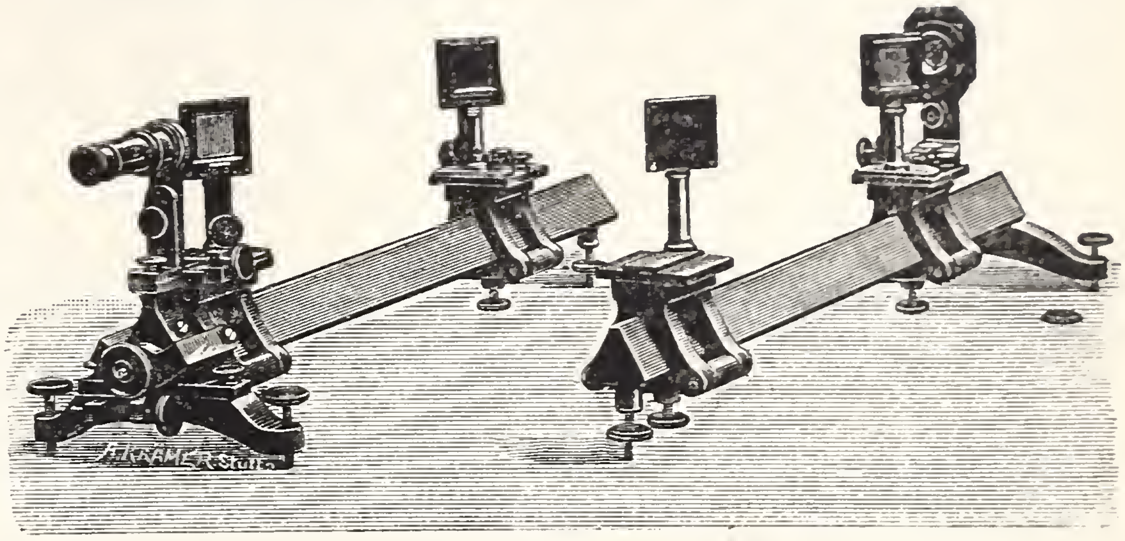
Mechanician to the Royal University of Würzburg.

Maker of Physical and Physiological Instruments of Precision.

(See also Section VI.)

Prof. Dr. L. Zehnder's Interferential Refractor.

The apparatus as shown in the illustration is fully described in the Zeitschrift für Instrumentenkunde 11. p. 275. 1891.



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6. Dr. Steeg & Reuter, Homburg v. d. H. (Bad Homburg).

Optical Institute. Established 1855.

Gold Medal: Naples 1870. Silver Medal: Moscow 1872. Progress Medal: Vienna 1873.
Diplomas: Graz 1880 and Frankfort-on-the-Main 1881. Gold Medals: Vienna 1883, Antwerp 1885.
Diploma and Gold Medal: Brussels 1888. Diploma and Gold Medal: Chicago 1893.

(See also Section Vb.)

A Collection of about 370 films of natural and artificial crystals for studying the optical properties of crystallized bodies in polarized light, in mahogany case.

This collection embraces:—Films of uniaxial crystals, ground at right angles to the axis, with positive and negative double refraction. Films of biaxial crystals, cleft at right angles to the acute bisectrix or otherwise. Films of substances producing circular polarization. Plates of crystals with embeddings. Twin-plate consisting of uniaxial and biaxial crystals. Plates and parallelepipeda of pleochroitic crystals. Films of substances giving rise to abnormal double refraction. Preparations of animal and vegetable substances acting on polarized light. Mica combinations after Nörremberg and Reusch. Finally, some of the most important accessories for investigations on polarized light, such as retarding films, wedges, coloured glasses, &c.

VI. Electrical Measuring Instruments for Scientific Purposes.

1. Hartmann & Braun, Frankfort-on-the-Main.

Makers of Electrical Measuring Instruments.

[See also Section IV.]

The factory was established in 1879 at Würzburg and transferred to Frankfort-on-the-Main in 1884. The establishment undertakes the construction and manufacture of all instruments required for exact electrical measurements, complete equipments of scientific and technical laboratories, stationary as well as portable, and also the manufacture of commercial electrical instruments, of which up to the end of 1899 some 80,000 have been supplied, adapted for potentials up to 30,000 volts and currents up to 20,000 ampères.

A special department is reserved for the preparation of materials for the safe wiring of dwellings.

The firm possesses physical laboratories for the preliminary investigations preceding the construction of new instruments and for testing and standardizing scientific measuring instruments.

Separate laboratories have been established for standardizing commercial instruments, last year's output amounting to 20,000 ampèremeters, voltmeters, wattmeters, ohmmeters and consumption registers.

Messrs. Hartmann & Braun have been the recipients of the highest awards on various international exhibitions.

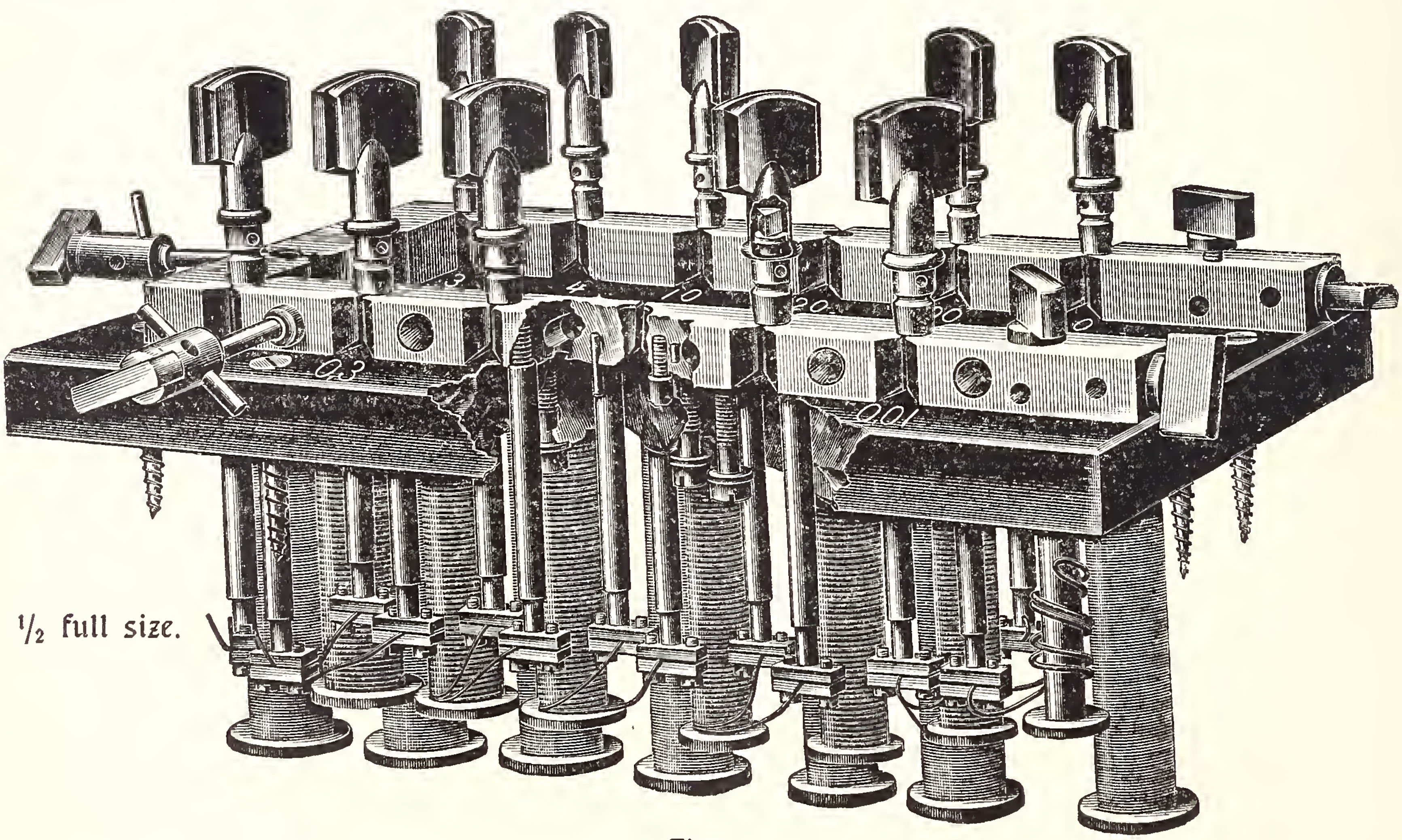

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Fig. 1.

1. **Standard Resistance Coils** after the models of the Imperial Physical and Technical Institute, of 0.1, 1, 10, 100, 1,000, 10,000 and 100,000 ohms (Firm's catalogue No. 552).

2. **Standard Resistance Coils,** for large currents, of 0.01 and 0.001 ohms (Firm's catalogue Nos. 553 and 554).

3. **Standard Cells** of the Clark type, modified by Kahle, and in Weston's form (Firm's catalogue No. 551).

4. **Resistance Boxes with Plug Connection,** of various ranges from 0.01 to 10,000 ohms. Fig. 1. These boxes were first introduced by Messrs. Siemens & Halske, but the exhibitors have added several improvements some of which have become typical.

In the place of the grouping usually adopted in sets of weights the following series has been introduced:—

0.01	0.1	0.2	0.3	0.4	and	0.1	1	1	2	3	4	
	1	2	3	4				10	20	30	40	
	10	20	30	40 &c.				100	200	300	400	&c.

Each block being fitted at the side with plug binding screws for shunting, this series renders the box available for self-comparison with the smallest number of plug-resistances, e. g. 1 may be compared with 1, 1+1 with 2, 1+2 with 3, &c. In addition, the beginning and end of each resistance are not joined to the same connection, as formerly, but are each connected separately, hence the sum of the individually measured resistances is equal to the resistances measured in the aggregate. The plugs are moreover of a deeper form; they require, it is true, more accurate fitting but are more readily extracted and do not so easily become locked in consequence of changes of temperature. The ebonite handles are conveniently shaped and fused on to the metal; they are so arranged as to obviate the production of thermo-currents at the plug contacts. In other respects the requirements of the Imperial Physical and Technical Institute have been followed.

5. **Lord Kelvin's Multi-cellular Voltmeters** (No. 595), for low potentials, reading to maxima of 65 to 500 volts and fitted with a larger or smaller number of cells. They have been modified so as to harmonize with other measuring instruments designed for industrial use. The troublesome oil-

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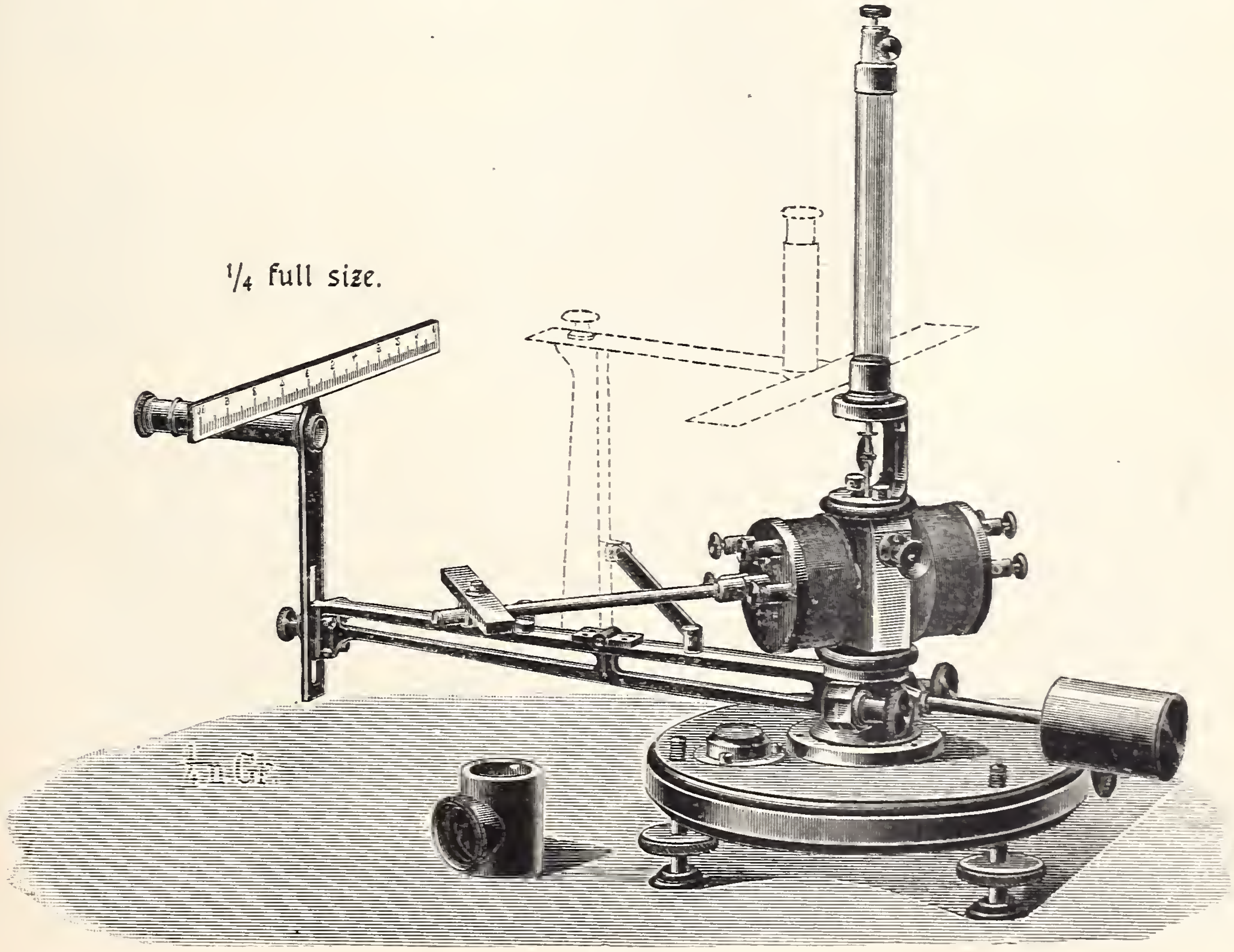

Fig. 2.

damper of the original instrument has been replaced by an efficient copper damper. These instruments are particularly useful for measuring potentials at distant points, e.g. the feeding points of a widely ramified system of cables, since the resistance of the feeder conducting wires need not be taken into consideration.

6. **Static Voltmeter** (No. 594) for extremely high potentials. The instrument is adjusted for 10,000 volts and consists essentially of two plates receiving similar charges, one plate being movable so as to be repelled, whilst at the same time it is attracted by a fixed plate connected with the other pole. The small movement is transmitted by a lever to a pointer. The distance between the fixed plates can be varied so that the instrument can be adjusted for any voltage or scale. All metallic parts are enclosed in a casing of highly insulating material so as to eliminate bodily risks.

7. **Small Pointer Galvanometer** (No. 366) with bell-magnet suspended by a cocoon fibre, with dead-beat action and bifilarly wound multiplier, with reliable arrester for transport and convenient means for rapid adjustment.

8. **Telescope Galvanometer** with aperiodically damped bell-magnet and astatizing magnet (No. 367 a). The bifilarly wound multipliers can be displaced so as to vary the sensitiveness while the resistance may or may not be varied. The deflections are read by a mirror and small telescope on a scale placed 25 cm away. The instrument gives accurate readings; it is compact and portable and can be set up in a few seconds. The sensitiveness of the instrument, when non-astatic, varies from 9 to 3×10^{-7} ampères per division according to the resistance of the coils. Fig. 2.

9. **Large Aperiodic Reflecting Galvanometer** (No. 371). This instrument embraces the combined advantages of Siemens's bell-magnet, Wiedemann's movable multipliers with Becquerel's winding, astatization by a Braun's soft iron screen-ring and various other appropriate mechanical devices. The sensitiveness, irrespective of astatization, corresponding to a deflection of 1 mm at a scale-distance of 1 m varies from 8 to 2×10^{-8} ampères, according to the resistance.

The bell-magnet is considerably reduced in size and modified in shape so as to carry 75 times its own weight. The substance of the copper used in the damper has also been considerably diminished without prejudice to the aperiodicity of the instrument. By these modifications the windings have been made to approach the poles of the magnet, and the sensitiveness has been increased correspondingly.

The screening ring is made in two parts in order to obviate polarity by changing the mutual position of the parts. The mirror is appropriately mounted and a convenient device is provided for Hauy's rod. Fig. 3.

10. **Astatic Reflecting Galvanometer with Vertical Magnets** (No. 372). The magnetic system consists of two vertical needles coupled close together, as used by Weiss in a later device, and possesses similar advantages as the bell-magnet, being besides excellently adapted for astatization. The system is suspended by a quartz fibre capable of adjustment in its length. The whole instrument is designed in such a manner that the vertical magnetic couple can be immediately exchanged for a Thomson or Rubens astatic magnetic system. It is particularly adapted for cable work. The sensitiveness when beating 10 seconds with a resistance of 5,000 ohms is 2.5×10^{-9} ampères per 1 mm deflection at a scale-distance of 1 m.

Galvanometer with fixed magnets. Hartmann & Braun were the first to recognize the advantages of the principle of the movable coil within a fixed permanent magnetic field as first applied in Thomson's syphon recorder and adapted by Deprez and d'Arsonval to the construction of galvanometers. The development of that principle has led to the construction of "Precision voltmeters" and "Precision ampèremeters" designed for industrial purposes and fitted with pivoted needles; moreover, by finer arrangements for the suspension and connection with the circuit, also by an improved form of coil and better intensity of the magnetic field, a degree of sensitiveness has been obtained which is otherwise not realizable except with troublesome astatic galvanometers; and, finally, various mechanical improvements have been introduced so as to considerably extend the applicability of the instruments. Fig. 4.

11. **Pointer Galvanometer** with movable coil (No. 536 a) and pivoted system. A deflection of 1° reads 0.000007 ampère.

12. **Portable Precision Millivoltmeter** (No. 601), with pivoted needles, circuit resistances for high potentials and shunt resistances for very large currents.

13. **Stationary Volt and Ammeter** for laboratory use, with coil suspended by a narrow strip (No. 530). Potentials and currents are measured almost concurrently, the instrument being provided with three ranges and means for rapid changing. The movable system can be securely clamped for transport. Fig. 5.

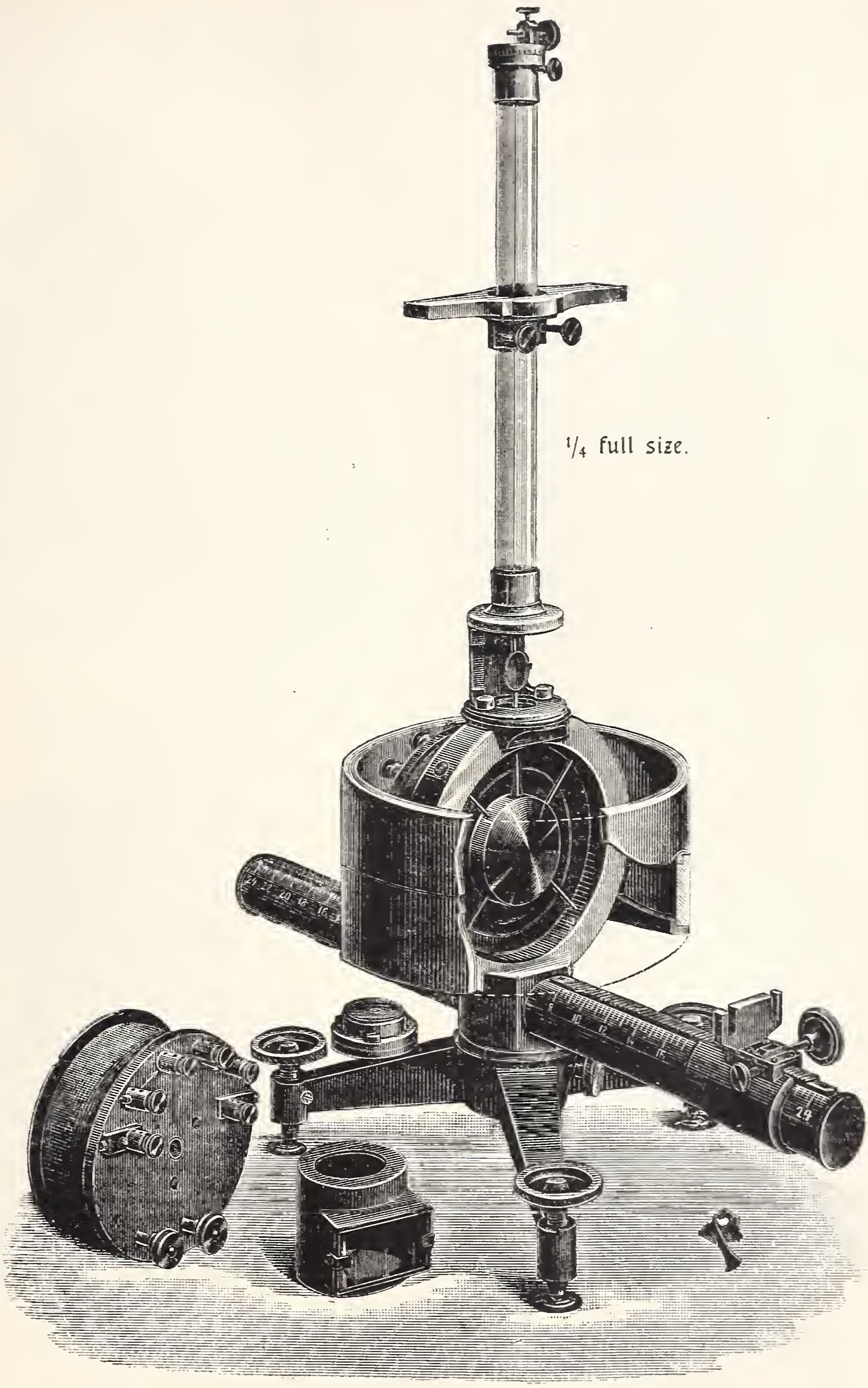

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Fig. 3

14. Reflecting Galvanometer, readily convertible into a ballistic instrument (No. 535 a) by altering the momentum of inertia. The movable coil contains two windings, one of high, the other of low resistance, one of the coils being short-circuited or closed by a rheostat so as to render the degree of damping adjustable. The sensitiveness is 1 mm = 9×10^{-10} ampères at a scale-distance of 1 m.

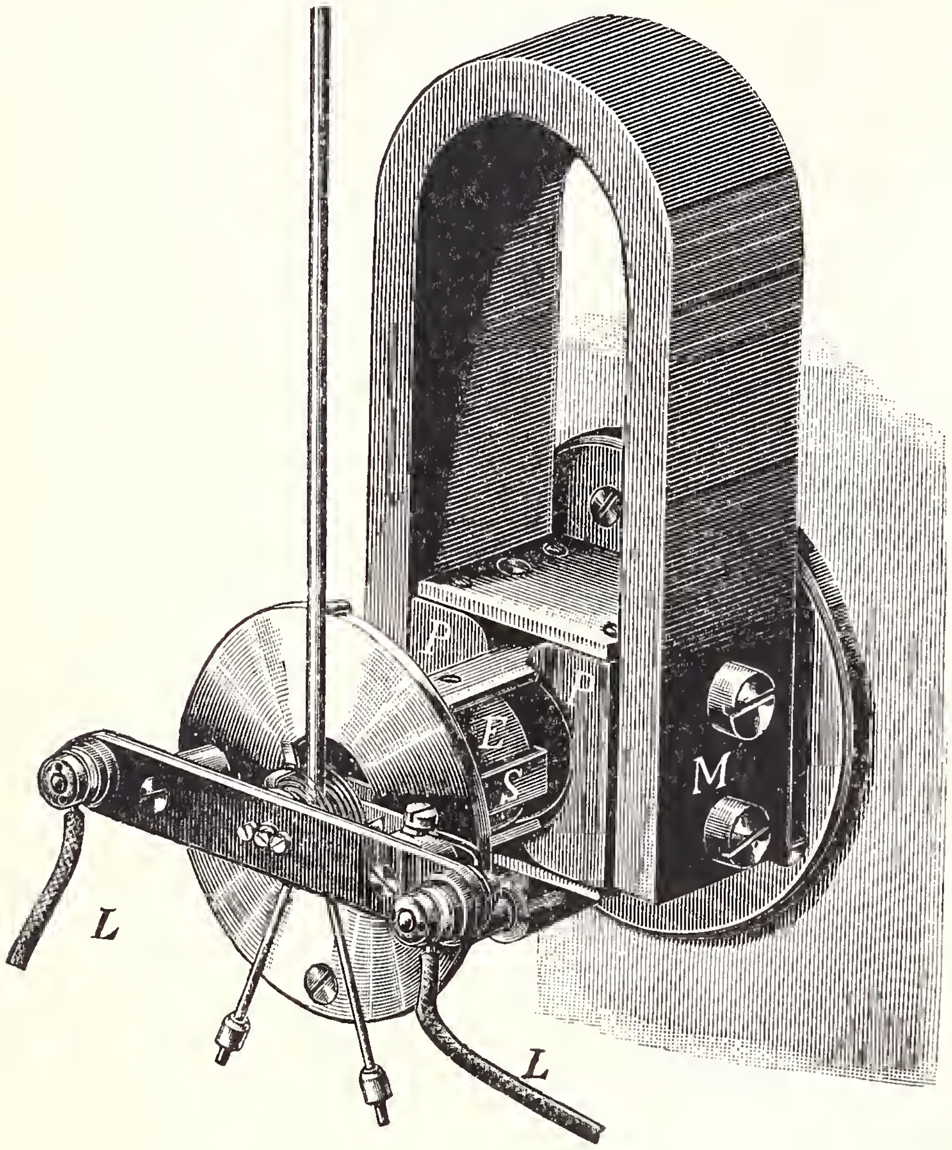

Fig. 4.

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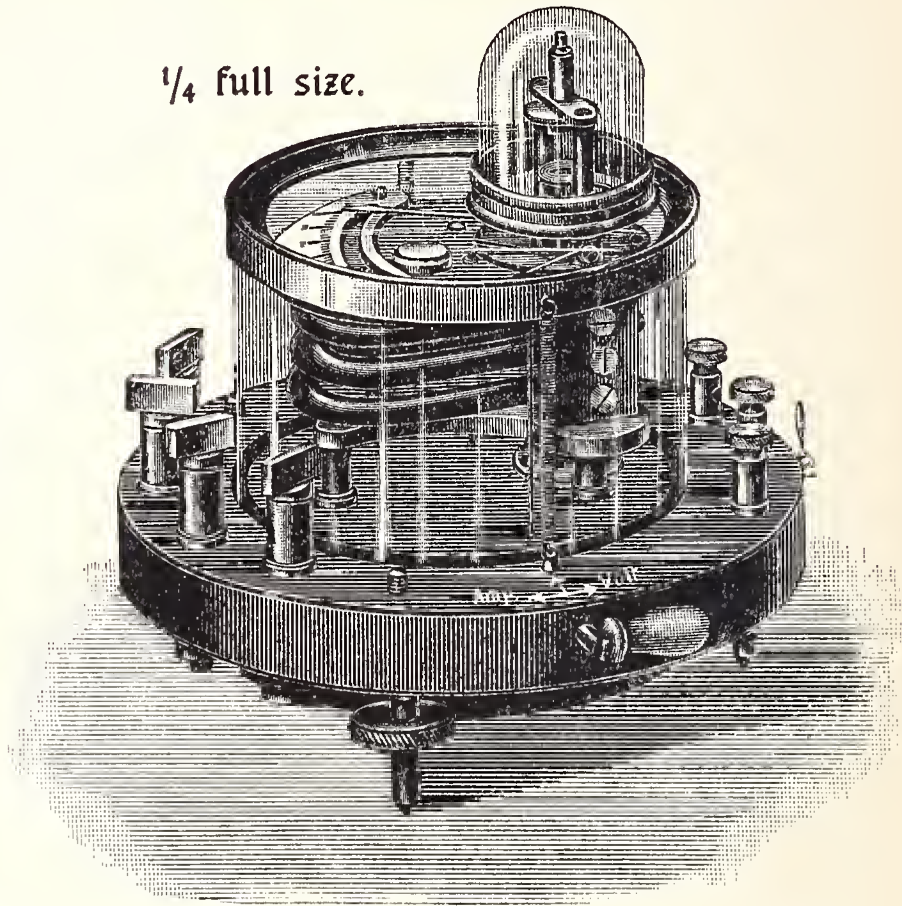

Fig. 5.

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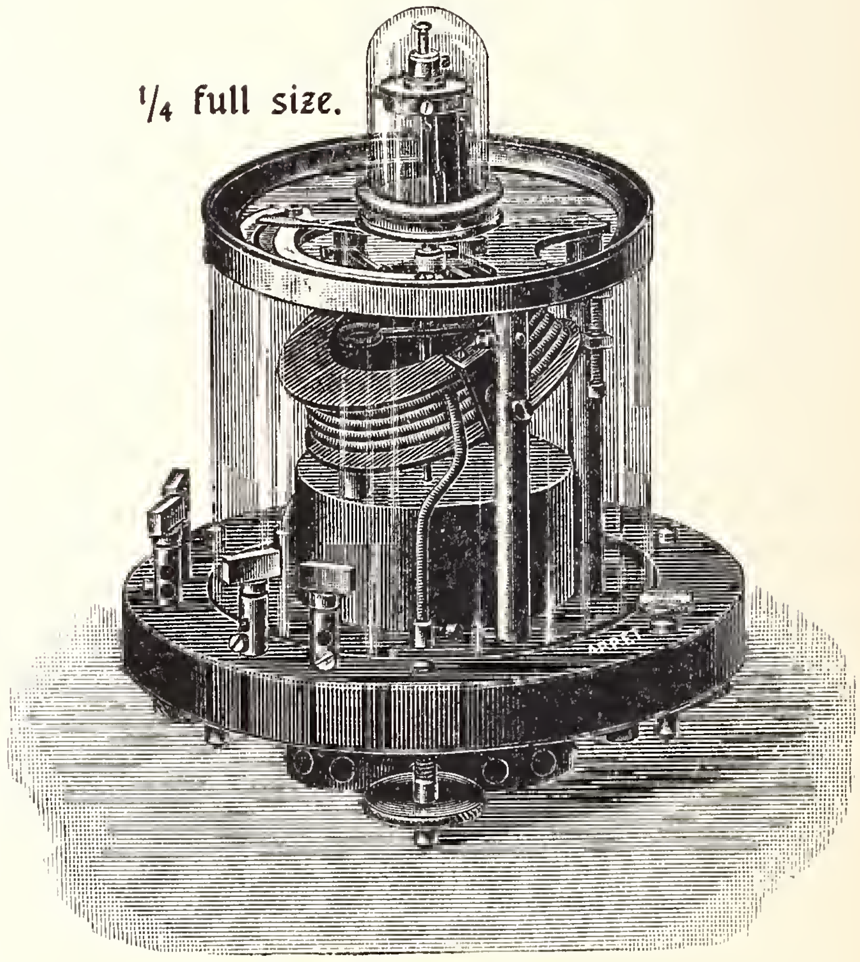

Fig. 6.

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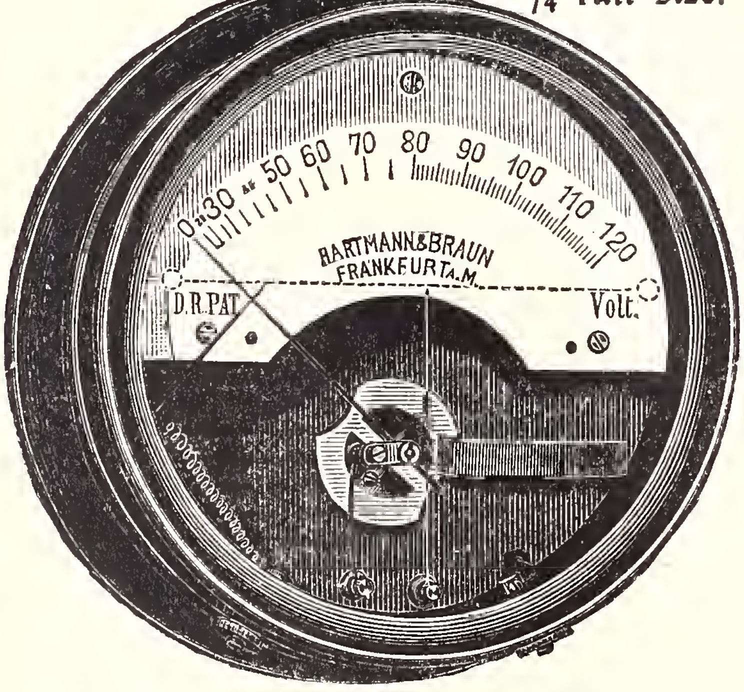

Fig. 7.

15. F. Kohlrausch's Reflecting Electro-dynamometer for Weak Currents (No. 378). The current enters the movable coil by the thin suspension wire and leaves by a platinum vane immersed in dilute sulphuric acid and serving as a damper. The instrument is sufficiently sensitive to demonstrate telephone currents.

16. Pointer Electro-dynamometer for Larger Currents (No. 531). A stationary obliquely mounted solenoid is made to act upon a movable pair of flat coils, the shape of which is such that one coil moves towards the strongest, the other towards the weakest field. The system is astatic and furnishes an almost uniform scale. Self-induction is extremely slight, and there is scarcely any mutual induction between the fixed and movable coils, the instrument is therefore available for alternating circuits with considerable phase displacement. The instrument has an almost perfectly aperiodic pneumatic damping device. Fig. 6.

17. Direct-reading Wattmeter for Continuous and Alternating Currents (No. 610), well damped, with almost uniform scale and constructed after the same principle as the preceding instrument. The stationary coil is wound for currents up to 1,000 ampères, and the instrument is rendered available for the highest potentials by circuit resistances. It can also be used with three-phase currents with uniformly loaded and uniformly displaced phases.

Hot Wire Volt and Ampèremeters. The slight elongation arising in a short measuring wire of platinum silver alloy when current is passed through it, is transmitted to the pointer axle through a wire attached at one end to the measuring wire and taken round a pulley mounted on the pointer arbor, the other end of this wire being held in tension by a spring. Means are provided to regulate the tension of the measuring wire and to compensate for external temperature variations. In Ammeters the current is made to enter the measuring wire at several points by means of flexible silver strips so as to reduce the loss of potential as far as possible. The movements of the pointer are aperiodic. The measuring wire will carry three times the maximum current for which the instrument is calibrated without damage. These instruments possess the advantage of being directly available for both continuous and alternating currents and are made either in the form of ordinary technical measuring instruments or as portable control instruments or self-recorders. About 20,000 of these instruments are in practical use. Fig. 7.

18. Portable Dead-beat Hot Wire Ampèremeter (No. 600a), with measuring ranges within 0.3 to 20,000 ampères with safety fuse against overloading. A special arrangement is provided for making the intervals almost perfectly uniform.

19. Stationary Hot Wire Ampèremeter (No. 598), with transformers, the saturation of which protects the wire from fusion due to overheating. This instrument is exclusively available for alternating currents, those of high potentials in particular (suitable shunt resistances are supplied for continuous currents).

The same principle has been applied to the construction of voltmeters for ranges from 1 to 30,000 volts, also with transformers in lieu of circuit resistances.

20. Portable Controlling Voltmeters (No. 600b). For potentials up to 200 volts, available for various ranges by subdivision of the circuit resistance. The heating wire is protected by a fuse of accurately adjustable resistance.

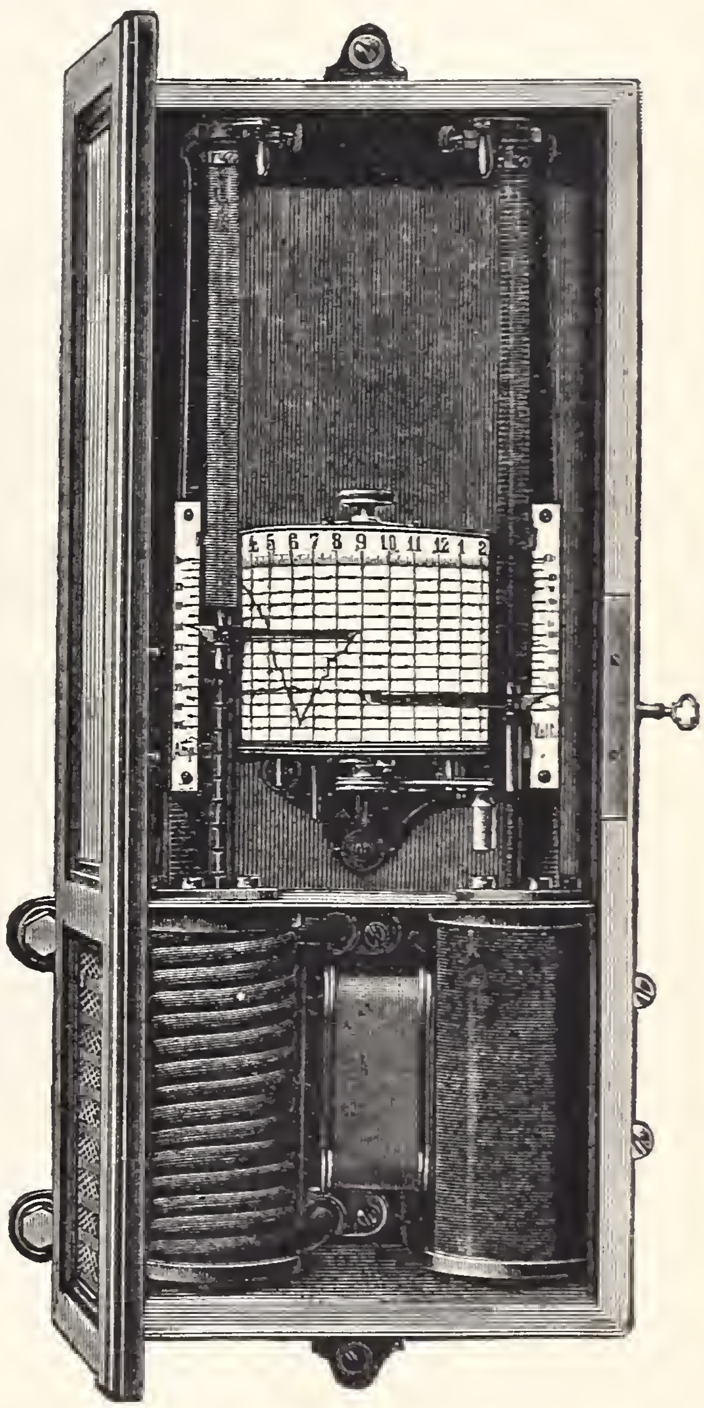

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Fig. 8.

Self-recording Instruments. The diagrams are traced in rectangular Cartesian coordinates with the aid of systems producing rectilinear movements or by the conversion of rotary into a reciprocating rectilinear movement.

21. Electro-magnetic Combined Volt and Ammeter (No. 539), on the principle of Kohlrausch's spring-galvanometer. These instruments are supplied for either purpose alone or as double Volt or Ammeter recorder for use in three wire circuits. The ammeters are also made with a charging time recorder for accumulators. Fig. 8.

22. Load Indicator for Alternating Currents, constructed on the principle of Ferraris's rotatory field.

23. Kohlrausch's Roller Metre Bridge (No. 389). The resistance of the metre wire, which has a length of 3 m, can be raised to its tenfold resistance by means of two shunts each having $4^1/_2$ times the resistance of the wire and available for shunting on either or both sides. The shunts supplied with the apparatus range from 1 to 10,000 ohms, the higher ones being wound by Chaperon's method. The bridge is principally adapted for the measurement of electrolytes. Fig. 9.

24. Sliding Contact Bridge (No. 407 e). Sliding resistances, which were formerly exclusively used as regulating resistances, have first been applied by Hartmann & Braun for the purposes of measurements. Naturally, the mechanical parts have been correspondingly improved with a view to obviate transition resistances. This type is far more convenient and quicker in use than the plug contact pattern.

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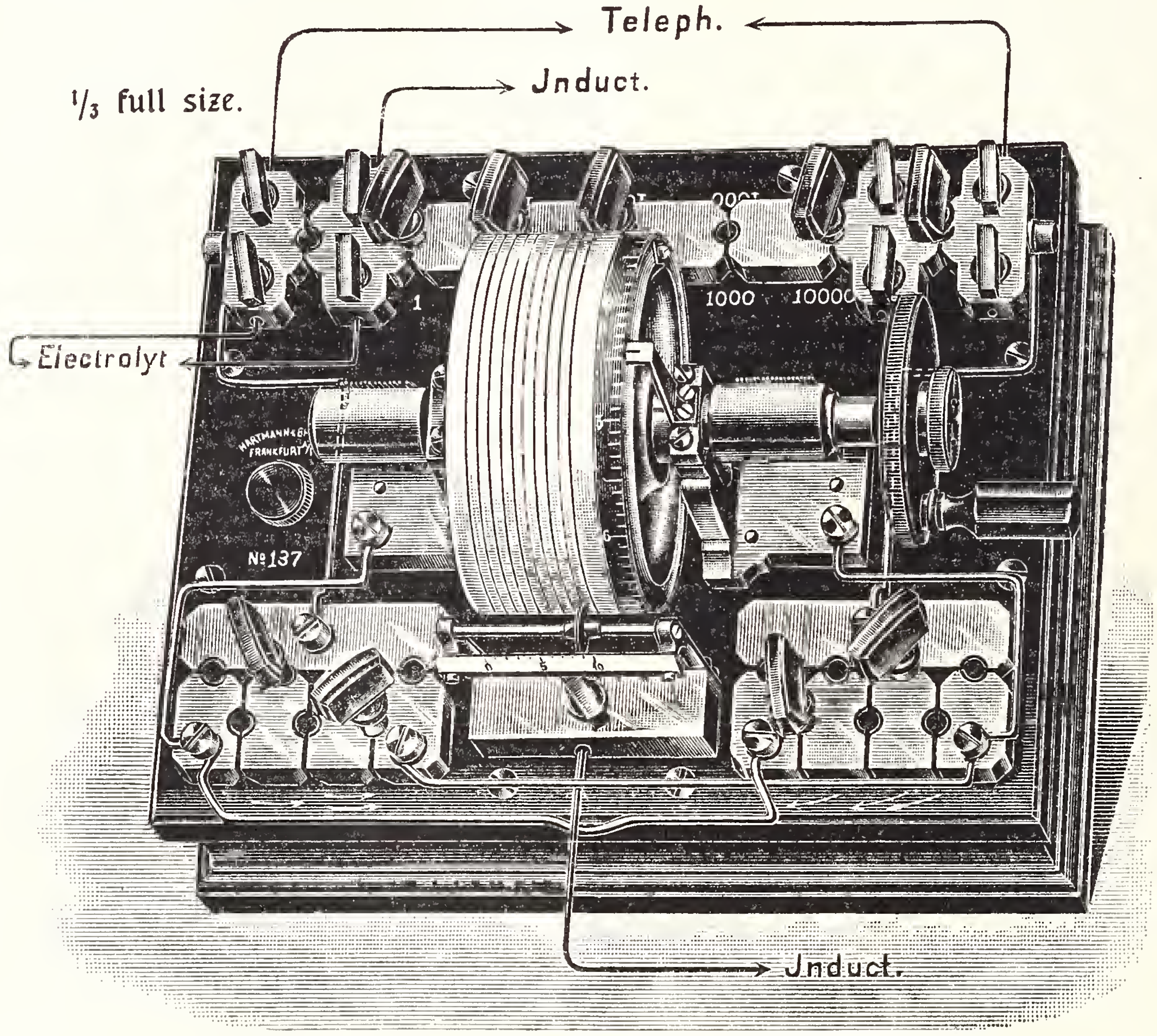

Fig. 9.

25. Nippoldt's Telephone Bridge (No. 452) for ascertaining the ground plate resistance of lightning conductors and telegraph earth conductors with the aid of alternating currents, fitted with arrangement for measuring with earth contact borers by Wiechert's method. The measuring apparatus is connected directly to a flat cased telephone, which can be put out of circuit so as to measure the resistances of inductive circuits with the aid of a small galvanometer.

26. Thomson's Double Bridge (No. 508 a), conveniently arranged for direct reading of resistances of 0.00001 to 7 ohms.

27. Ohmmeters (No. 614) for direct reading of resistances independently of the strength of the measuring battery and the influence of terrestrial magnetism. The entire scale can be made available for any range up to 1 megohm and for any interval.

The instrument is also extremely convenient for temperature measuring from a distance. Resistance thermometers for use in conjunction with this instrument are adapted for any required purpose.

28. Kohlrausch's Universal Metre Bridge (No. 388) for measuring solid and electrolytic resistances by means of a galvanometer or telephone, reading direct from 0.01 to 10,000 ohms. The galvanometer in conjunction with outside resistances or shunts is also available for measuring potentials and currents, and has in this particular instrument three ranges.

29. Potentiometer with Sliding Contacts. This type enables a quick and easy balance to be obtained between the ends of the circuit by turning the switch lever, and the results are directly read off for all ranges. The apparatus contains as a special feature two circular sets of resistances which by turning a handle can be placed with the beginning and end of each set at any point of the circuit without altering the aggregate resistance.

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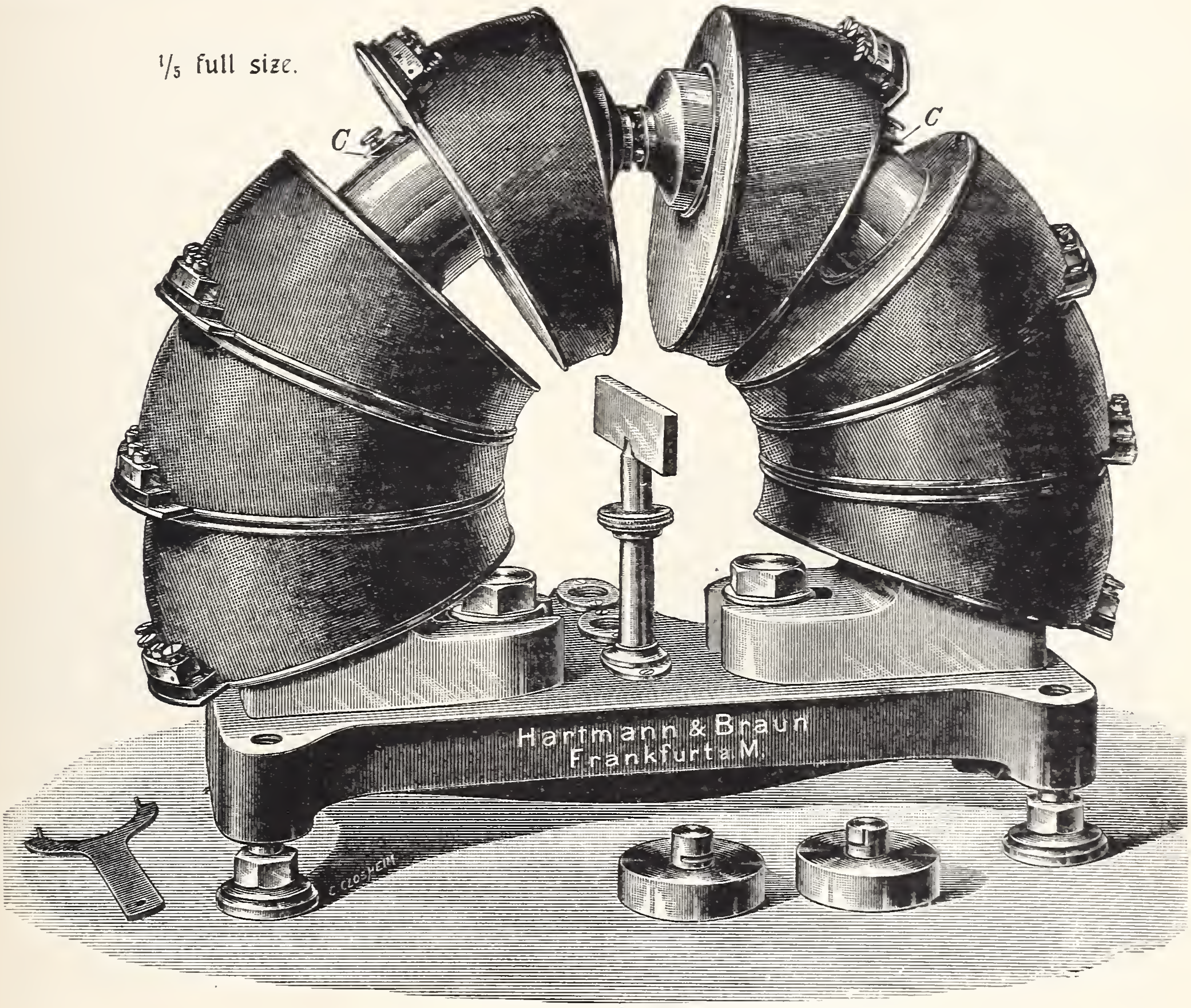

Fig. 10.

30. Complete Sets of Instruments for determining the capacity of cables by means of standard mica condensers and modified Sabine keys, on marble slab with all necessary connections, mounted on ebonite pillars. This outfit together with the apparatus necessary for testing insulations, is either mounted for stationary use in laboratories or fitted up in cable testing cars equipped with all desirable conveniences.

These outfits are exemplified by illustrations.

31. Apparatus for Examining the Quality of Iron with respect to their magnetic properties by means of a bismuth spiral (No. 560 a), consisting of an electromagnet fitted with double yoke the magnetizing coil of which takes the trial bar and bismuth spiral, a metre bridge with galvanometer for determining the resistance of the latter, a temperature compensator and an ampèremeter to ascertain

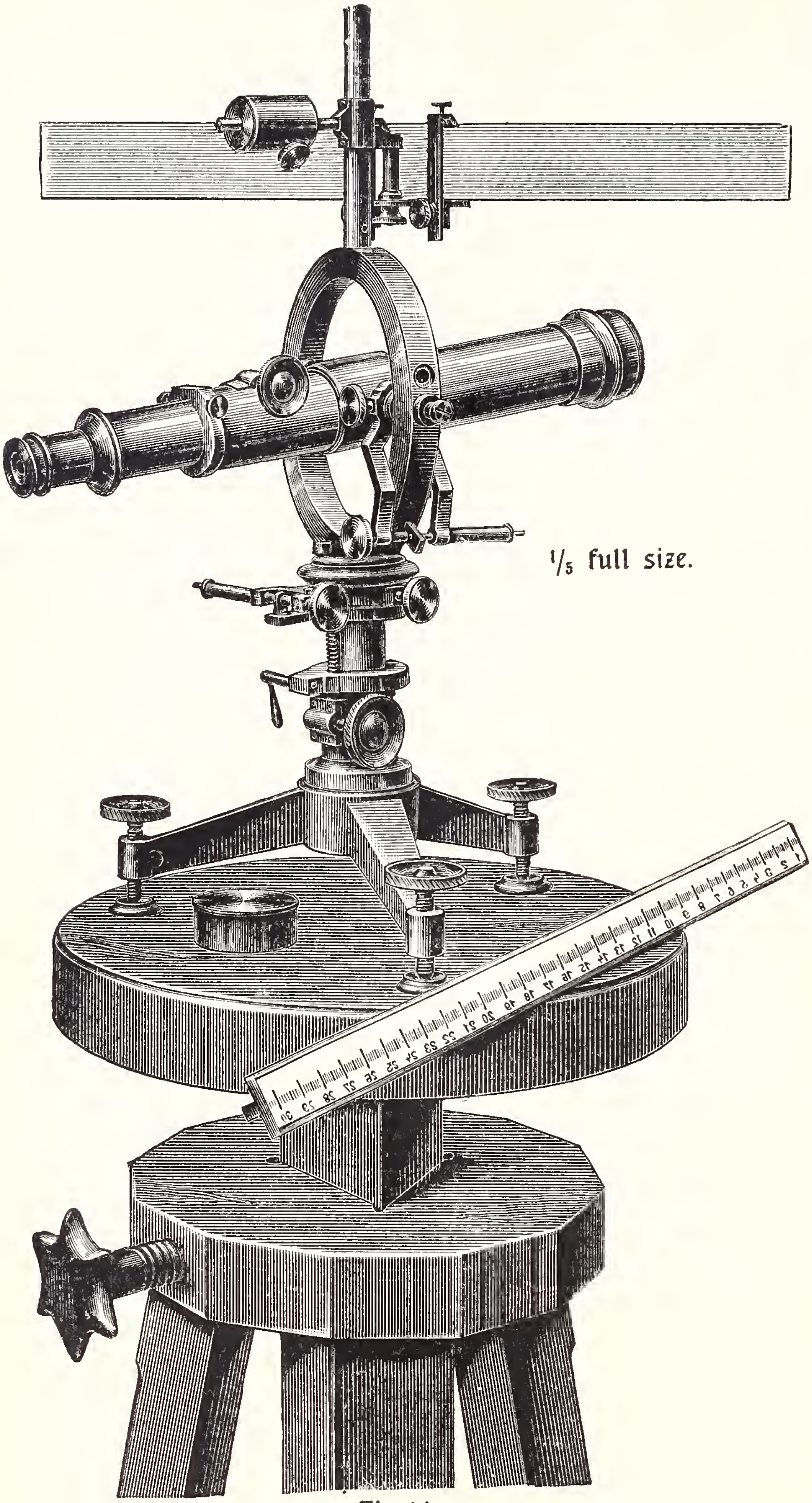

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Fig. 11.

the strength of the field. The scale of the metre bridge gives direct readings of the number of the lines of force.

32. Lenard's Bismuth Spiral (No. 504) for ascertaining the intensity of a magnetic field by measuring the variation in resistance of the spiral, which undergoes average changes of 5 per cent per 1,000 lines of force.

33. H. Du Bois's Large Half-ring Electromagnet. The magnet arms are made to slide apart and to turn with respect to each other. The pole ends are pierced and filled with cylindrical and conical caps with bayonet joints, for optical experiments. Each arm is fitted with four coils having an aggregate number of 2,500 turns shunting on to various sources. 72 volts and 20 ampères yield a magnetic field of 35,000 C. G. S. with an interferric 1 mm long and having a section of 32 qmm. Fig. 10.

34. H. Du Bois's Small Half-ring Electromagnet. Similar in construction to the larger magnet. The whole can be tilted 90° so as to place the polar axis of the interferric space in a vertical direction. The attainable magnetic field is 20,000 C. G. S.

35. Large Reading Telescope for magnetic and electric reflecting instruments (No. 357), absolutely free from iron, with fine adjustment in azimuth and altitude. The telescope has considerable light-gathering power and is fitted with a euryscopic micrometer-eyepiece. The scale carrier can be raised and lowered; in addition, the entire instrument can be moved up and down by a rack and pinion attached to the foot. Fig. 11.

36. Small Reading Telescope with simple mechanism for accurate adjustment with respect to the mirror (No. 358).

37. Scale Lantern with electric incandescent filament for projecting the deflections of reflecting galvanometers upon opaque or transparent scales, fitted with convenient adjustments (No. 362 b).

38. Gauss's Stand for Instruments with three oak feet weighted with lead and a light stage which can be raised or lowered and clamped (No. 349 a).

39. Scales for Mirror Readings, in lengths of 40 to 140 cm (Nos. 360 and 361), made of crystal-glass, milk-glass, wood covered with paper or transparent celluloid. All scales are accurately graduated on the dividing engine. The milk-glass scales have proved particularly suitable for telescope readings.

2. Keiser & Schmidt, Berlin, 20 Johannisstr.

1. **Induction Coil** giving a spark of 50 cm. In making this coil, particular attention is paid to perfect insulation of the primary and secondary coils, and also to the proper adaptation of the apparatus if required for use with contact-breakers of very high frequency.

The contact-breakers, viz. Wagner's hammer, Deprez's contact-breaker and mercury balance, are fitted to a slide so as to render them interchangeable.

The condenser consists of three divisions and its capacity can be regulated by a lever to 2, 4 or 6 microfarads.

2. **Condensers.** By the use of chemically pure paper and a special insulating mass these condensers are made nearly as constant as those of mica plates. By means of plug connections the capacity can be varied from 1 to 2, 3, 5, 10 microfarads and above.

3. **Voltmeter,** 0 to 5 volts, reading to 0.5 volt.

4. **Voltmeter** for class demonstrations, 0 to 10 volts, reading to 0.5 volt with pointer visible from both sides.

5. **Ampèremeter,** 0 to 20 ampères, reading 0.5 ampère.

6. **Ampèremeter** for class demonstration, 0 to 10 ampères, reading to 0.5 ampère with pointer visible from both sides.

7. **Millivoltmeter,** likewise available as a pyrometric galvanometer for measuring temperatures of 0 to 1,600° C. German patent No. 99,274. This galvanometer is of the Deprez-d'Arsonval type, the suspension of the system being patented. The index plays over two scales, one of which indicates the E. M. F. in millivolt, so as to facilitate the control of the readings furnished by the instrument, while the other reads directly degrees of temperature. The thermo-electric couple consists of two wires of pure platinum and an alloy of platinum and 10 per cent rhodium fused together at one end.

The E. M. F. of the thermo-electric couple at 1,600° C. is about 16 millivolt.

8. **Sensitive Millivoltmeter,** available as a galvanometer for measuring low temperatures as far as −240° C. in connection with Linde experiments. The galvanometer is of the same type as the preceding instrument, but the movable system is suspended by a thin wire. The couple consists of iron and constantan wire yielding, at a temperature of −240° C., an E. M. F. of about 9 millivolt.

9. **Prof. H. Rubens's Thermopile,** consisting of 20 couples of iron and constantan wire 0.1 mm thick. The pile has an E. M. F. of 1,000 microvolt per 1° C.

10. **Precision Resistance Box with Plug Connection,** after the patterns of the Imperial Physical and Technical Institute. The bobbins are wound with covered manganine wire.

11. **Plug Resistance Box in Decades.** Each decade consists of 10 equal resistances which are put into circuit by a single plug so as to avoid intermediate plug resistances as in serial resistance boxes.

12. **Bridge Shunt Box** with two arms of 1, 10, 100 and 1,000 ohms each, which can at pleasure be interchanged by two plugs.

13. **Decade Sliding Resistance Box** from designs of the German Telegraph Service, Experimental Department.

14. **Wheatstone Bridge with Plug Connections,** consisting of a resistance box of 0.1 to 1,000 ohms, two shunts of 1, 10, 100 and 1,000 ohms, in each and a double key. The shunt can, at pleasure, be put into circuit with either bridge arm. The double key is for the purpose of putting the battery and galvanometer into circuit.

15. **Wheatstone Bridge of Decades,** comprising resistances of 10×0.1, 1, 10, 100 and 1,000 ohms and two shunts of 1, 10, 100 and 1,000 ohms each. Each decade has one plug only.

16. **Wheatstone Bridge with Sliding Resistance Box and Sliding Contacts,** with two shunts of 10, 100 and 1,000 ohms each and five decades, in accordance with the requirements of the German Telegraph Service, Experimental Department.

17. Standard Resistance Coils as adopted by the Imperial Physical and Technical Institute. These resistances are enclosed in perforated metal cases and suspended in petroleum baths either for accurately ascertaining their temperature or for rapidly carrying off the heat generated by the current.

18. Clark Standard Cell, with thermometer in metal case, as used at the Imperial Physical and Technical Institute. The standard E.M.F. of the cell at a temperature t° and within the interval of 10 to 25° C. is 1.433 volt − 0.0012 (t−15) volt.

19. Prof. Feussner's Compensating Apparatus. This apparatus is for measuring potential differences between 0.01 and 1,000 volts and, with the aid of standard resistances, also currents between 0.001 and 1,000 ampères with a degree of accuracy within 0.1 per cent.
This apparatus is made in two forms, viz. a small model having a fixed resistance of 90,050 ohms and a large model having resistances of 1 to 200,000 ohms.

20. Trough Battery with Pachytrope.

21. Dry Cells. These cells have been worked continuously for 187 days by the Imperial Physical and Technical Institute and have been certified to yield, in conjunction with an external resistance of 20 ohms, 166.6 ampère hours at a mean P. D. of 0.74 volt, i. e., 123 watt hours.

3. E. Nöhden, Berlin, 7/8 Reichstagsufer.

Mechanician to the Physical Institute of the University.

Paalzow-Rubens's Dynamo-bolometer for measuring electrical oscillations of short periodicity. This apparatus has been employed by Prof. Rubens to investigate the influence of parallel wire gratings upon electric oscillations, as well as the distribution of the energy in electrically oscillating wires.

The exhibit is the property of the Physical Institute of the University of Berlin.

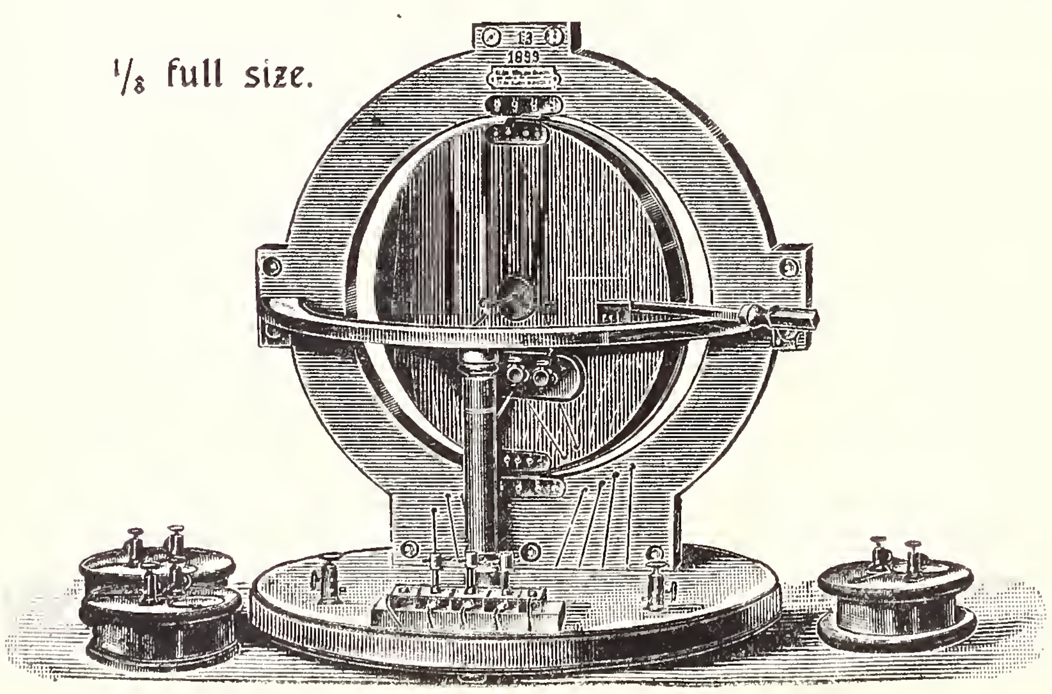
4. Wilhelm Siedentopf, Würzburg.

Mechanician to the Royal University of Würzburg.

Maker of Physical and Physiological Instruments of Precision.

(See also Section Vg.)

1/8 full size.



Prof. Dr. Max Wien's Apparatus for Varying Self-induction.

This apparatus, as shown in the illustration, is fully described in Wiedemann's Ann. 57. p. 249. 1896.

Prof. Dr. Max Wien's Unit Coils of Self-induction.

These coils are shown at the right and left of the illustration, and are described in Wiedemann's Ann. 58. p. 553. 1896.

5. Siemens & Halske Limited, Berlin.

(See also Sections IV, Va and VII.)

1. **Standard Resistances** of manganine with brazed copper arcs for connection, in two sizes, with protecting vessel serving at the same time as a receptacle for the petroleum used for maintaining a constant temperature.

These resistances are standardized accurately within $^1/_{10000}$ of their values and may, if required, be tested and certified by the Imperial Physical and Technical Institute. The thermal coefficient is below 0.00002 per 1° C.

a. Small pattern: 0.001, 0.01, 0.1, 1, 10, 100, 1,000, 10,000 ohms. Fig. 1.

b. Large pattern, in petroleum bath with turbine and water cooling spiral, for powerful currents: 0.001, 0.0001 ohms.

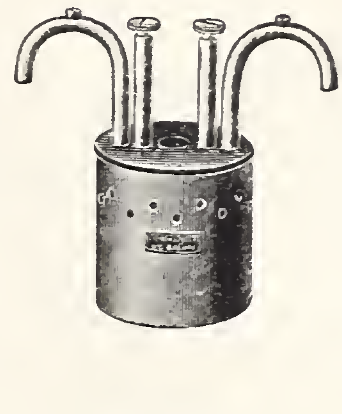


Fig. 1.

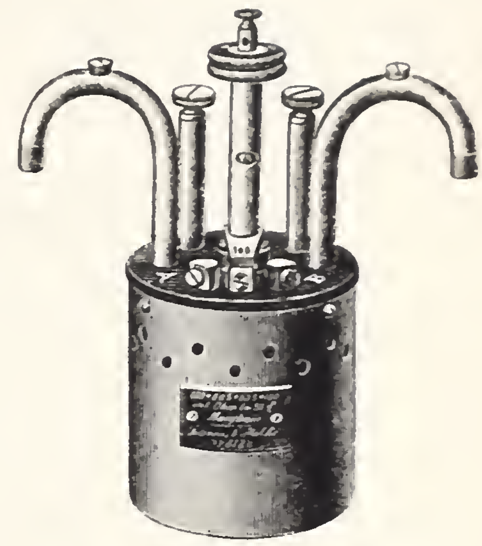


Fig. 2.

2. **Compensating Apparatus** for very exact measurements of potential and current after the compensating method of Poggendorff and Dubois-Reymond. Fig. 3.

The voltage can be measured within limits of 0.00001 to 1 volt and 1 to 1,500 volts by comparison with the E. M. F. of an encased standard cadmium cell requiring no temperature correction. Any other standard cell, e. g. a Clark cell, may be used, if the proper correction be made for temperature.

The current is measured indirectly by determining the P. D. at the terminals of one of the standard resistances specified under No. 1.

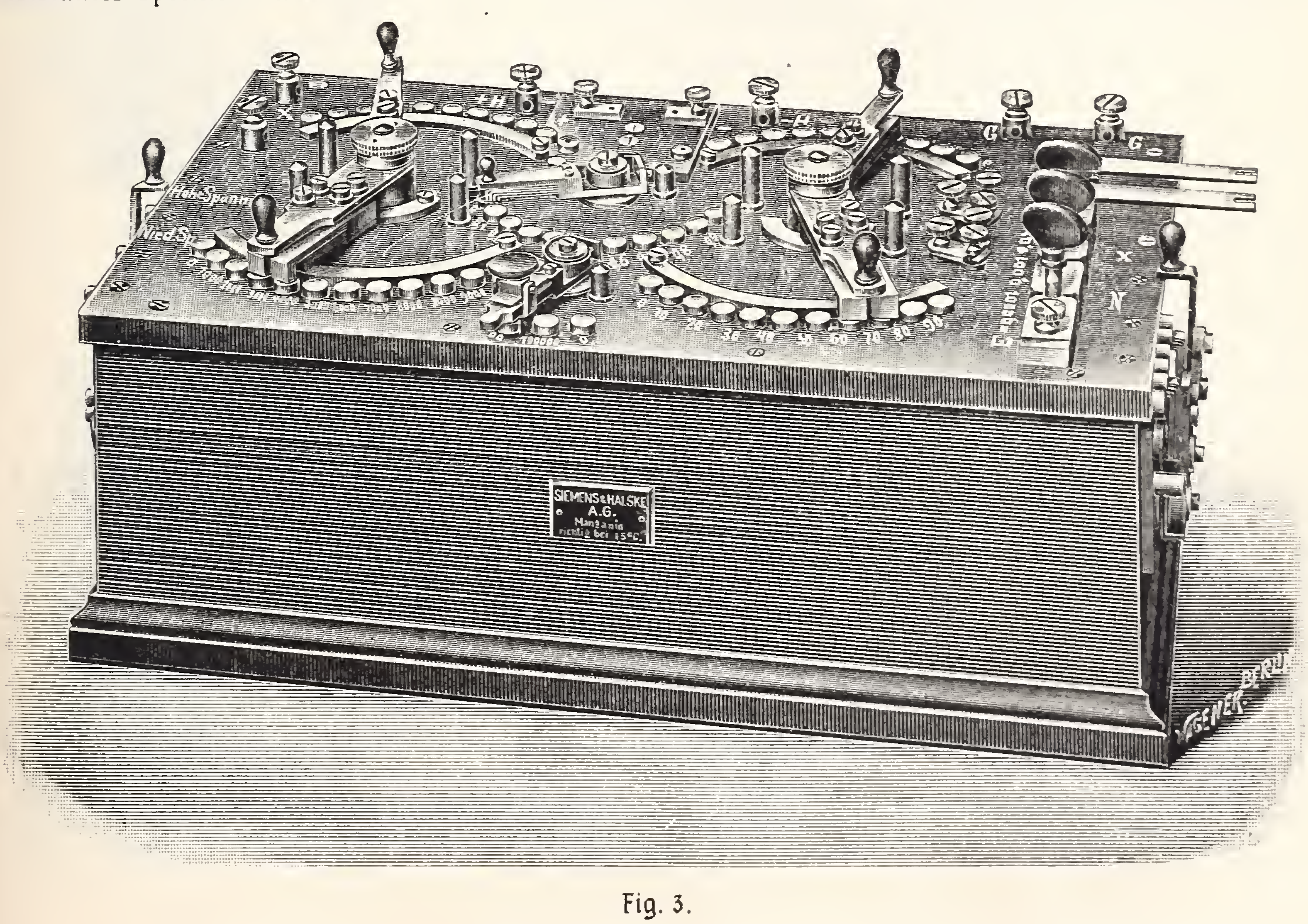


Fig. 3.

Accessories:—

1 Sliding contact resistance, accurately adjusted. Aggregate resistance 160,000 ohms. Fig. 4.

1 Deprez-d'Arsonval reflecting galvanometer, with fixed magnets and suspended movable coil, having a resistance of 1,000 ohms. Figs. 5 and 14.

1 Vertical reading scale for the reflecting galvanometer, with incandescent lamp, the image of the slit being visible on a horizontal scale. The scale is mounted along the wall immediately above the measuring instrument and the whole, being arranged in a compact form, can be controlled with great ease. Fig. 5.

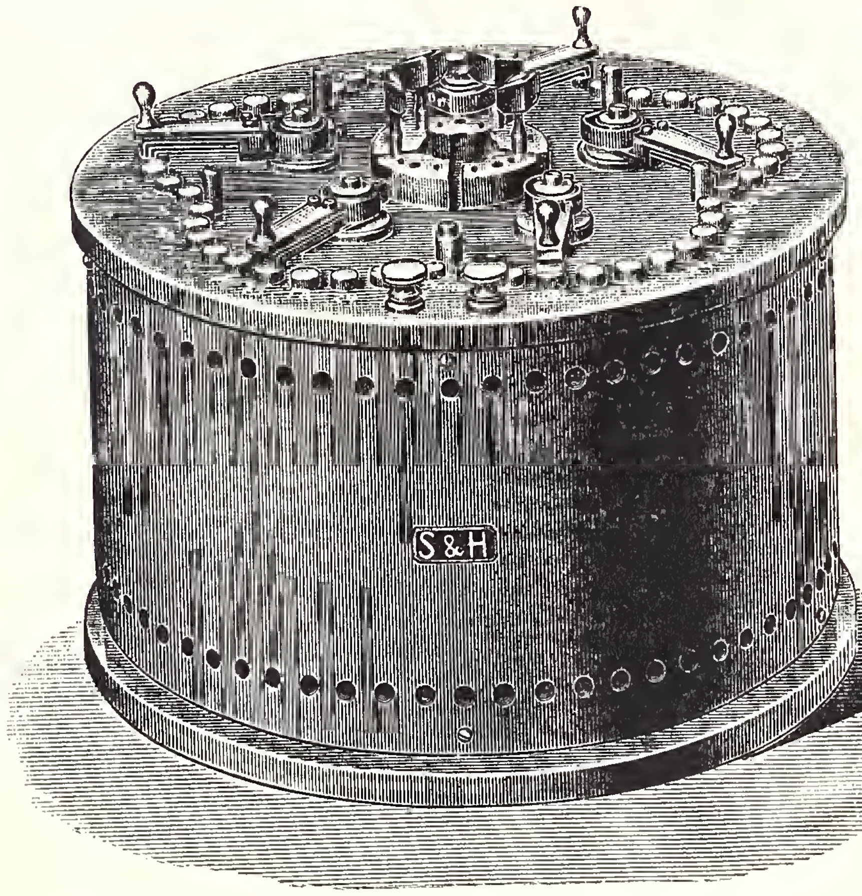


Fig. 4.

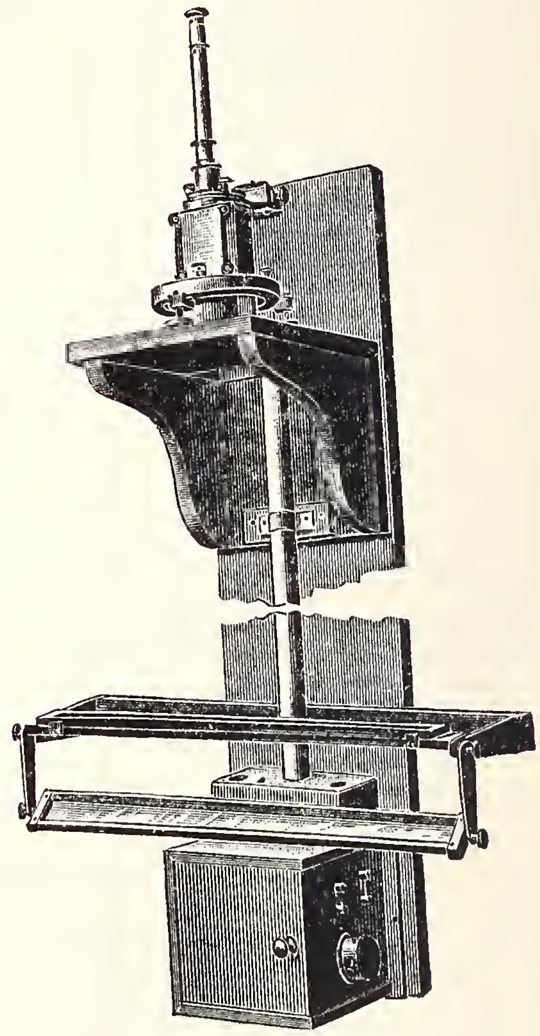


Fig. 5.

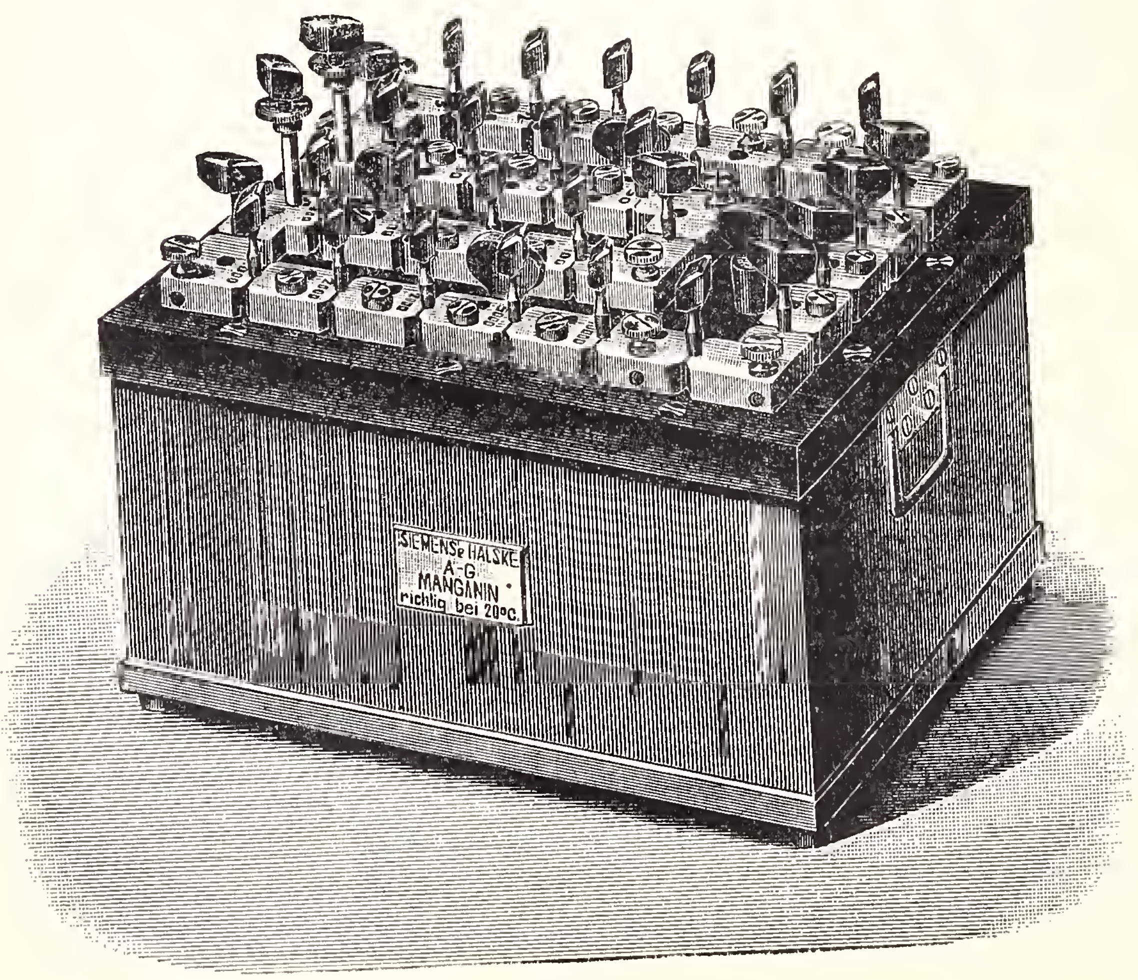


Fig. 6.

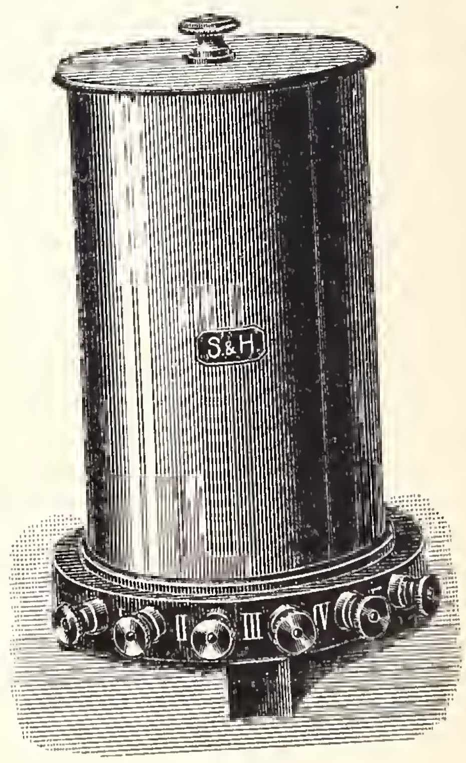


Fig. 7.

3. **Kohlrausch's Plug Resistance Box.** Aggregate resistance 20,000 ohms, compact arrangement, in steps from 0.1 to 10,000 ohms, with closed plug series, absolutely free from induction and capacity. Fig. 6.

The resistances above 200 ohms are wound after Chaperon's method. Their accuracy is within $^{1}/_{2000}$ of the specified value. With the aid of infinity plugs certain sets of resistances can be disconnected and used in separate circuits.

4. **Graphite Resistance** of 100 million ohms, not accurately adjusted, free from induction and capacity. The entire resistance is divided into 5 sections of about 10 to 50 million ohms arranged on a spiral groove cut into an ebonite cylinder with brass envelope. Fig. 7.

5. **Sliding Contact Resistance,** accurately adjusted for laboratory work with weak currents, fitted with ebonite cover. Aggregate resistance 10,000 ohms, with 5 cranks for 5 divisions of 9×0.1, 9×1, 9×10, 9×100, 9×1,000 ohms. Each of the cranks is put in circuit by copper spirals so as to render them independent of the transition resistances at the axis. Fig. 8.

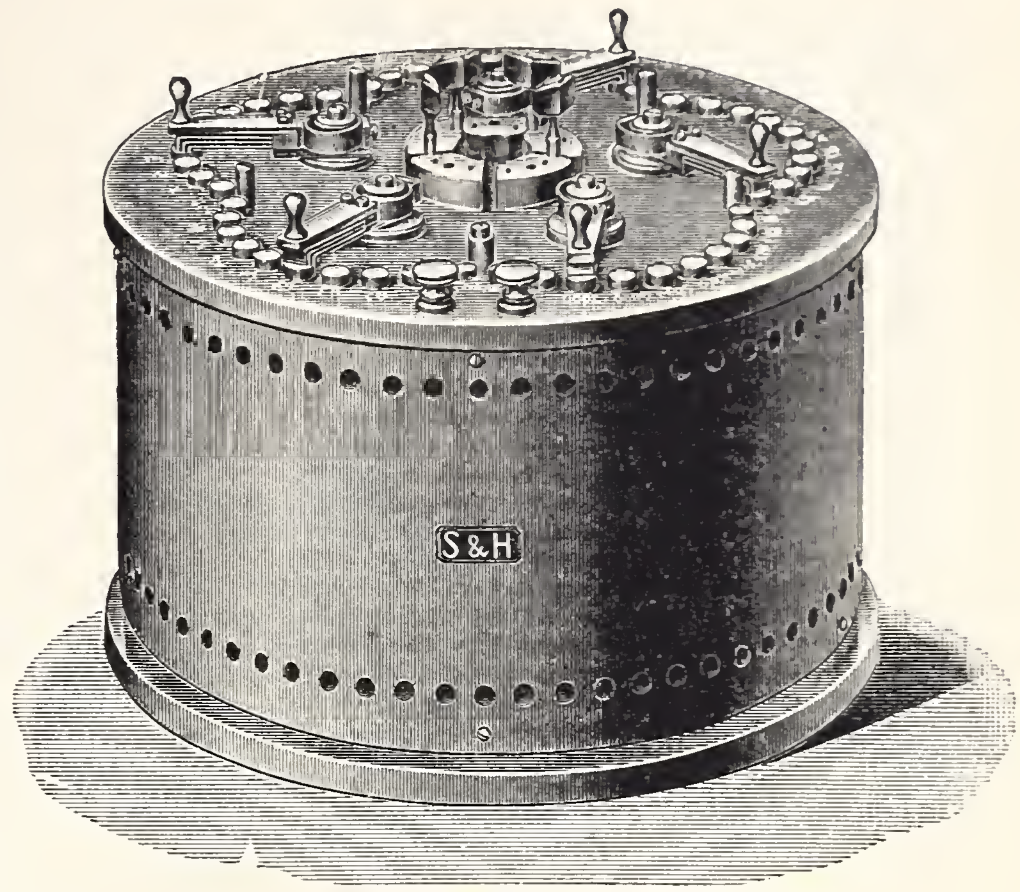


Fig. 8.

6. **Sliding Contact Resistance** not accurately adjusted, for weak currents, with wooden cover. Aggregate resistance 100,000 ohms, with 4 cranks for 4 sections of 9×10, 9×100, 9×1,000, 9×10,000 ohms and a fifth crank for a wire of 10 ohms for resistances under 10 ohms. Fig. 9.

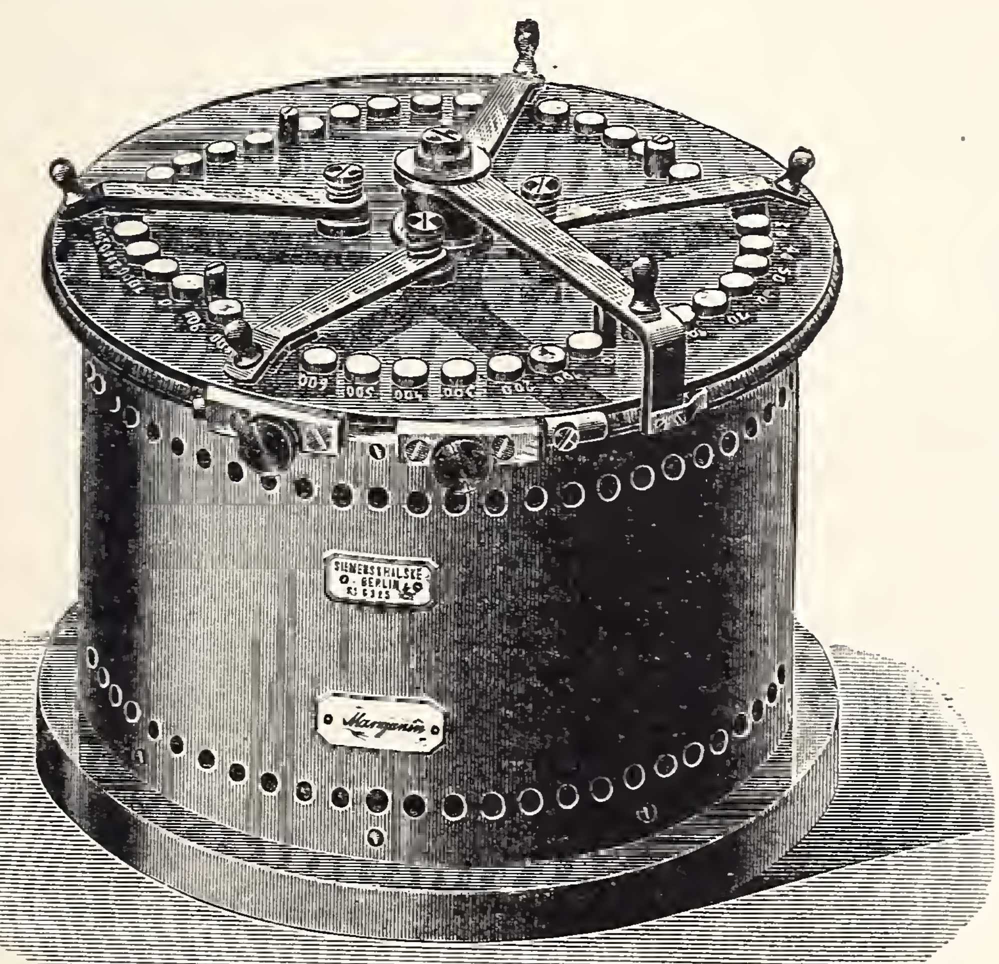


Fig. 9.

7. **Adjustable Resistances** for powerful low potential currents for laboratory and standardizing purposes, with automatic water cooler; consisting of 5 manganine tube resistances of 0.006, 0.012, 0.04, 0.08, 10 ohms for currents up to 3,000, 2,000, 500, 300 and 20 ampères. The individual resistances can, with the aid of couplings, be joined up in series or put out of circuit, or adjusted to any desired degree by sliding contacts. Fig. 10.

8. **Mica Condenser** of 1 microfarad, in mahogany box fitted with ebonite cover, for laboratory measurements and available as a comparison standard, in 4 sections of 0.1 to 0.5 microfarad. Fig. 11.

9. **Paper Condenser** in mahogany box fitted with ebonite cover, for technical purposes (telegraphy, &c.) of about 20 microfarads. In 3 sections, from 5 to 10 microfarads.

10. **Thomson's Electro-static Voltmeter,** for measuring high potential continuous and alternating currents and available for testing the insulation of conductors carrying a high voltage. In

metal box for screening off external static influences. The instrument is absolutely independent of the periodicity and has a double range of 1,000 to 5,000 and 2,000 to 10,000 volts. Fig. 12.

For still higher voltages the instrument is supplied with porcelain shunting condensers.

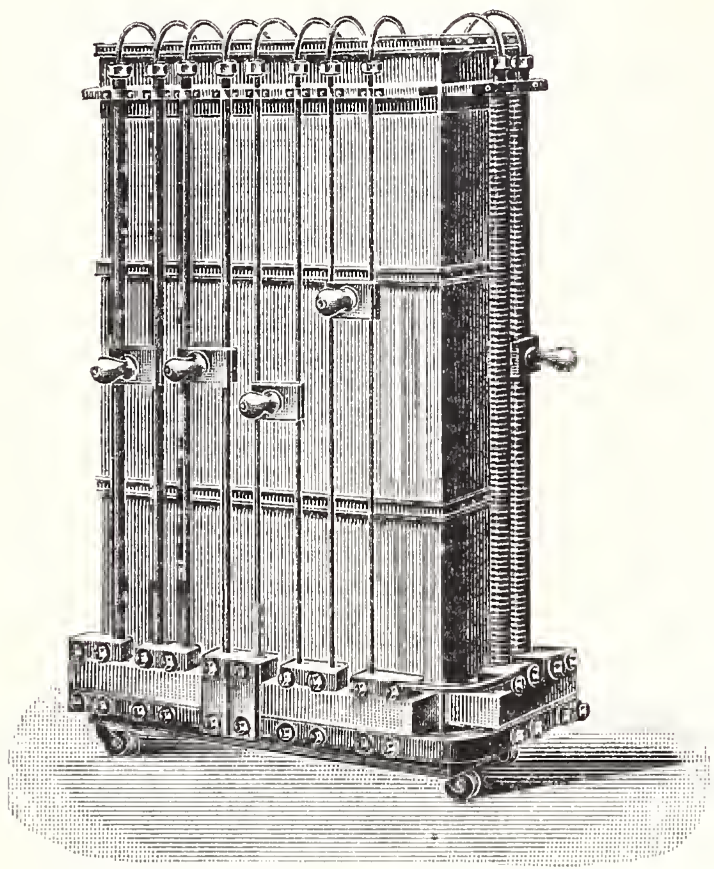


Fig. 10.

11. Astatic Reflecting Galvanometer, available as a cable detector galvanometer, fitted with bell-magnets, plane mirror, needle arrester, two directing magnets adjustable by toothed wheels and four interchangeable coils of copper wire; mounted on brass tripod. The resistance is about 16,000 ohms. Fig. 13.

The galvanometer tube is fitted with an adjustable compensator for diminishing the disturbances in the earth field.

12. Deprez-d'Arsonval Reflecting Galvanometer with fixed needles and movable coil giving a proportional deflection and a definite zero point. This instrument is a very sensitive current gauge, 1 mm of deflection at 1 m from the scale being $= 8.5 \times 10^{-10}$ ampères. The system carrying the movable coil is interchangeable with another of high potential sensitiveness, 1 mm of deflection at a distance from the scale of 1 m reading 3×10^{-8} volts. Figs. 14 and 15.

Accessory:— 1 Adjustable magnetic shunt for diminishing the sensitiveness by about 40 per cent.

13. Du Bois and Rubens's Double Coil Spherical Iron-clad Galvanometer, with two concentric spherical shells and a cylindrical shell serving as a transporting case, including a heavy and a light system of deflection magnets, two pairs of internal and two external directing magnets, two coils of 2,000 ohms each, together with two extra coils of 5 and 100 ohms respectively, and all other accessories. Fig. 16.

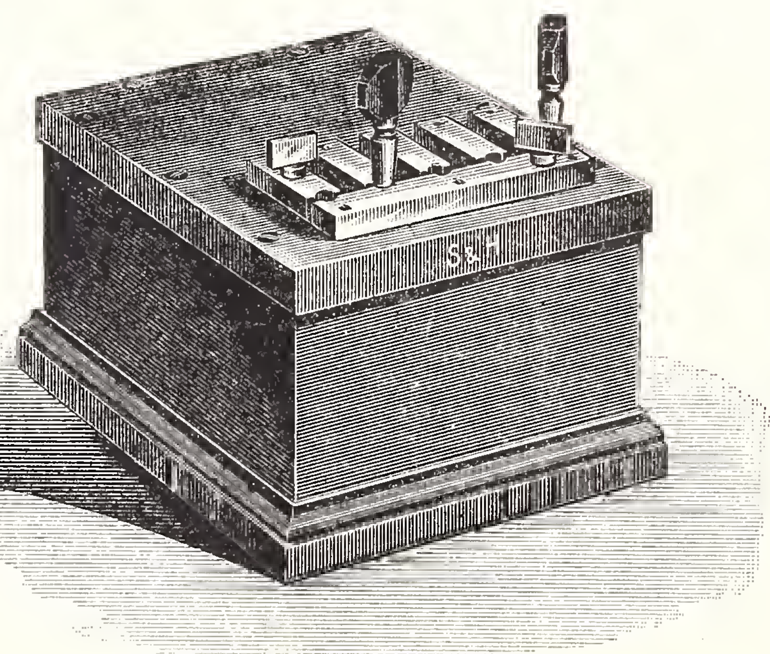


Fig. 11.

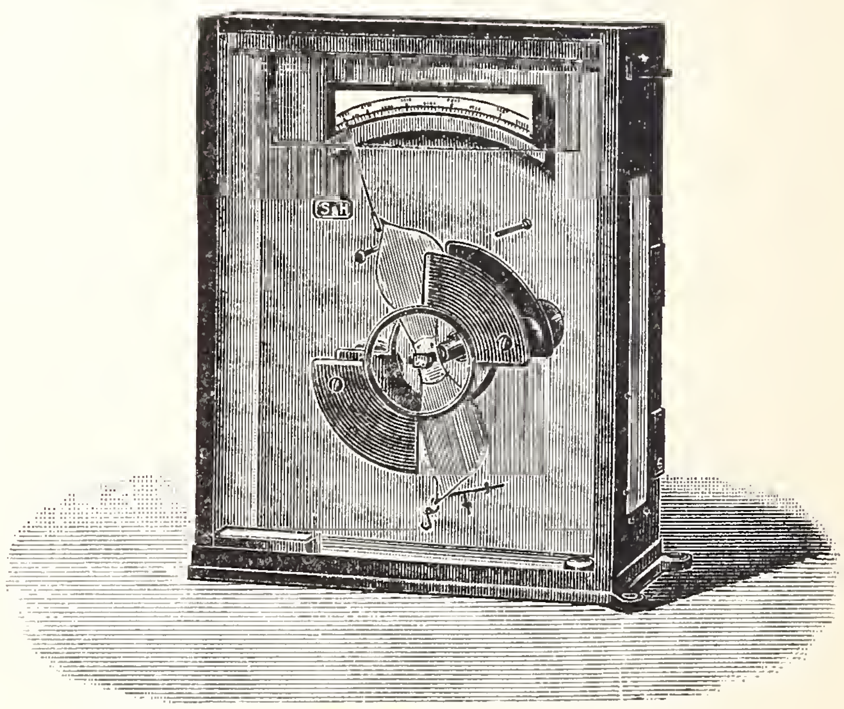


Fig. 12.

14. Du Bois and Rubens's Four Coil Astatic Iron-clad Galvanometer, with two concentric cylindrical shells, one of which is vertically movable, together with a light and a heavy magnetic shell, four external directing magnets and four coils of 2,000 ohms each in ebonite cases, together with four extra coils of 100 and 5 ohms respectively, and all other accessories. Fig. 17.

15. Precision Milli-volt and Ampèremeter, having a resistance of 1 ohm, for continuous currents, with absolutely proportional scale of 150 divisions. The instrument is nearly aperiodic and fitted with a well balanced movable system. Fig. 18.

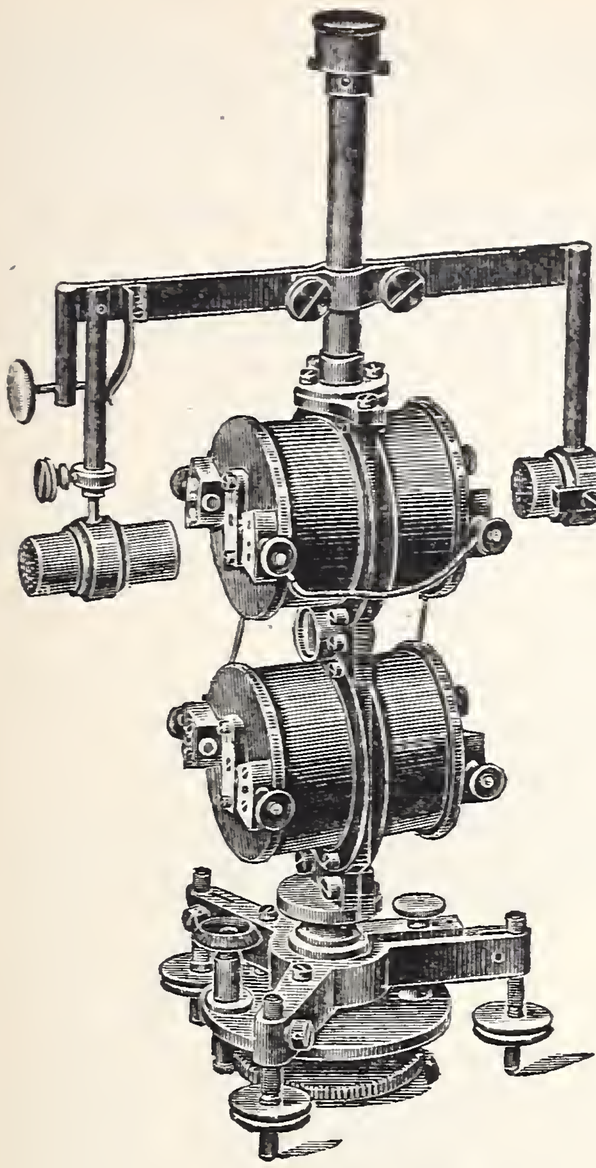


Fig. 13.

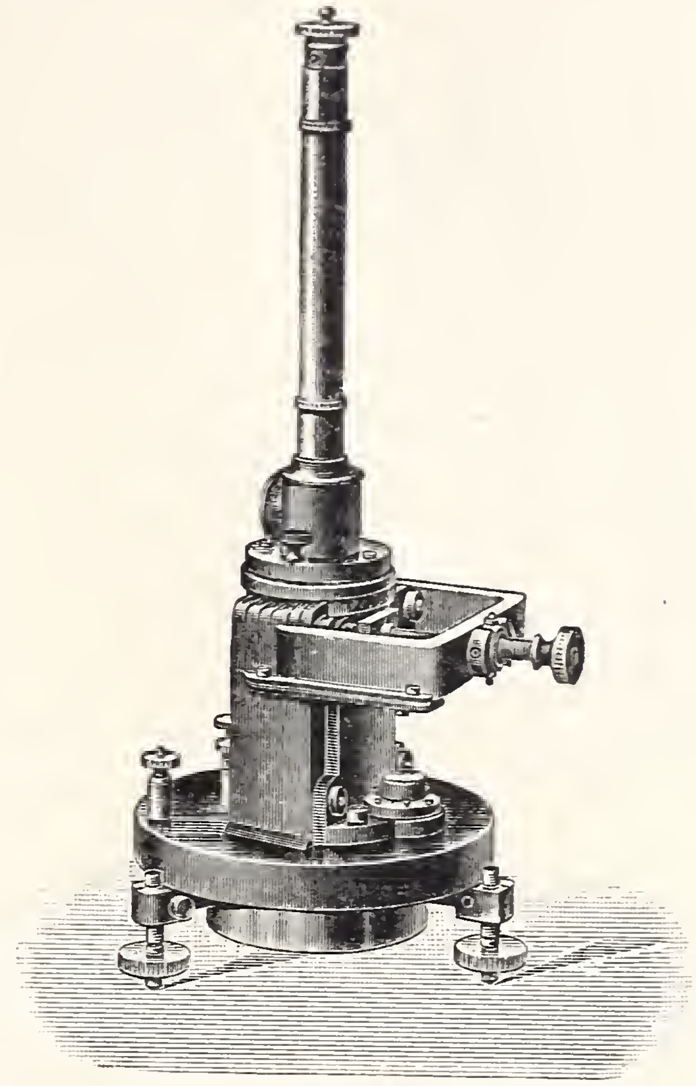


Fig. 14.

Fig. 15.

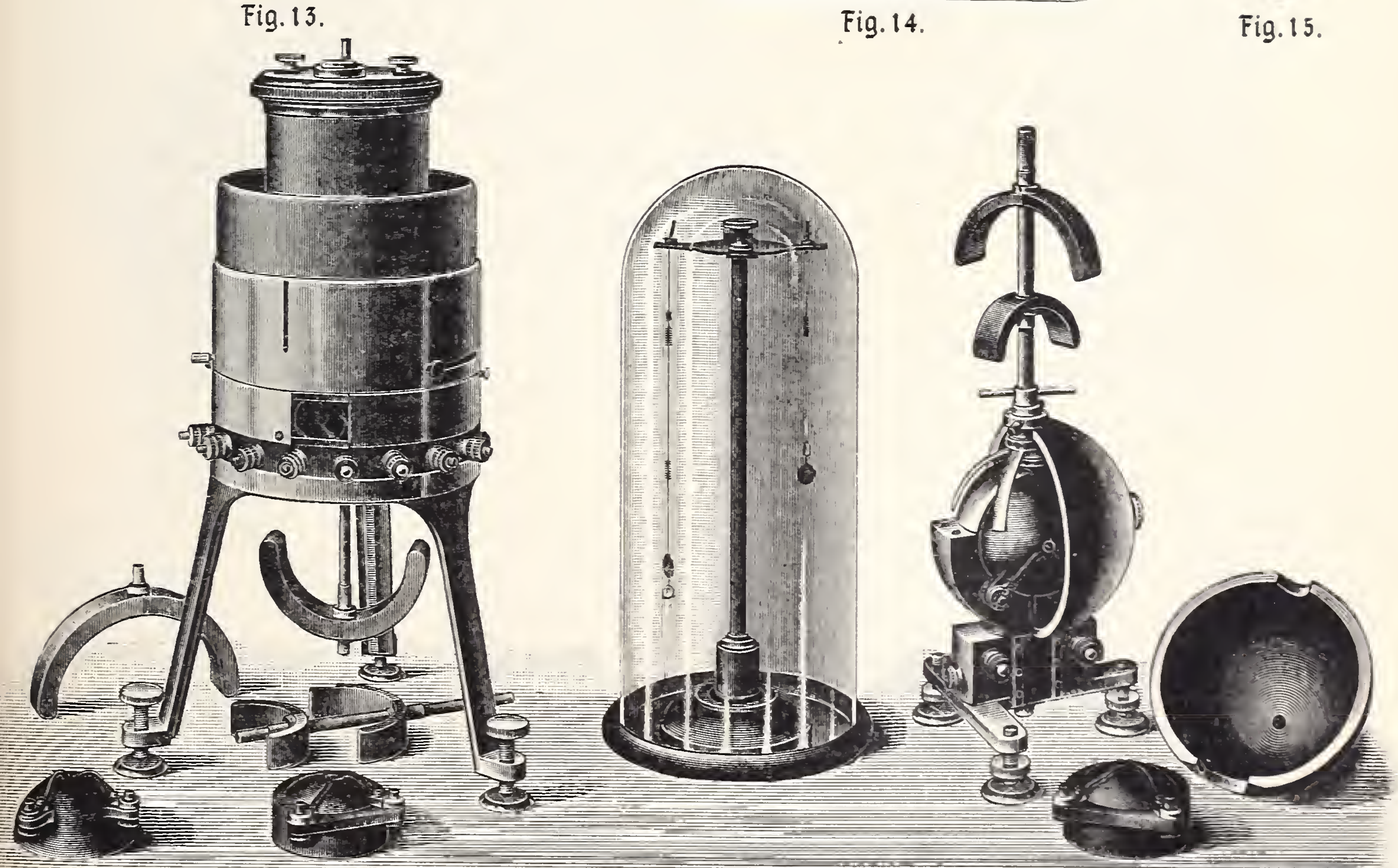


Fig. 17. Fig. 16.

The measuring capacity of this instrument without resistance or shunts extends from 0 to 0.15 volt and 0 to 0.15 ampère.

Accessories: 1 Resistance coil of manganine of 9, 99 and 999 ohms for measuring potentials of 1.5, 15 and 150 volts. Fig. 19.
1 Resistance coil of manganine of 9, 99, 999, 4999 ohms for measuring potentials not exceeding 750 volts.
1 Shunt of manganine of $^1/_9$ ohm for currents not exceeding 1.5 ampère. Fig. 20.
1 - - - - $^1/_{99}$ - - - - - 15 ampères.
1 - - - - $^1/_{999}$ - - - - - 150 -
1 - - - - $^1/_{1999}$ - - - - - 300 -

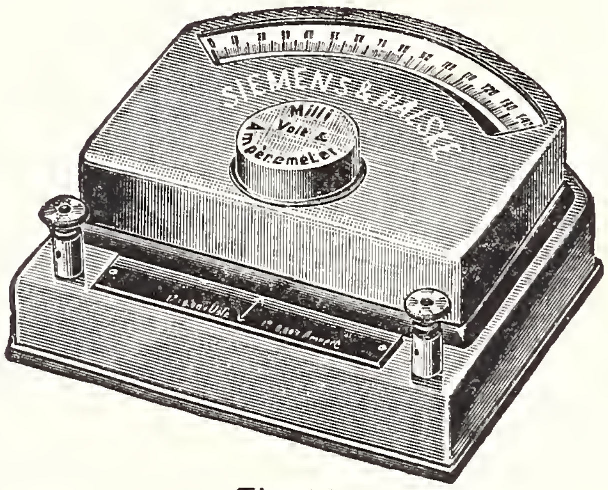


Fig. 18.

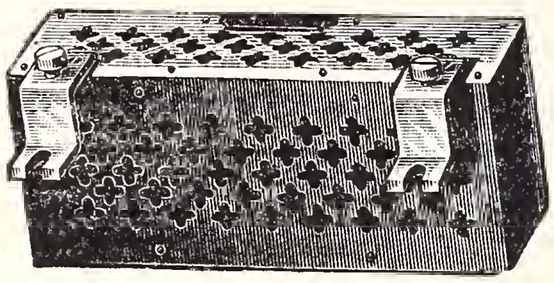


Fig. 20.

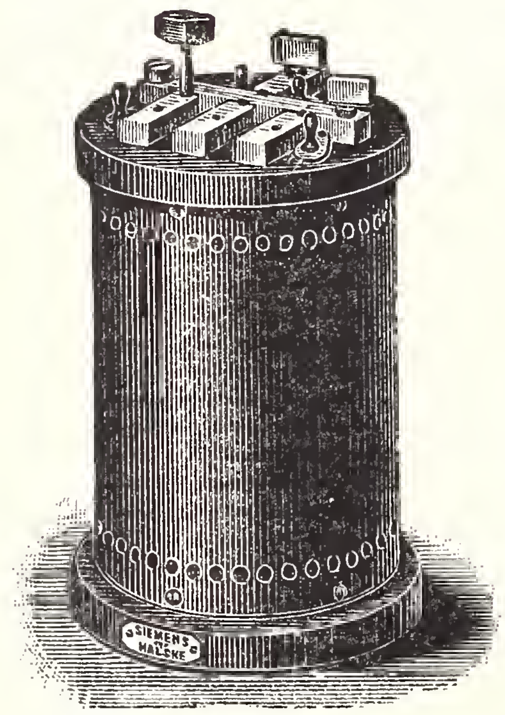


Fig. 19.

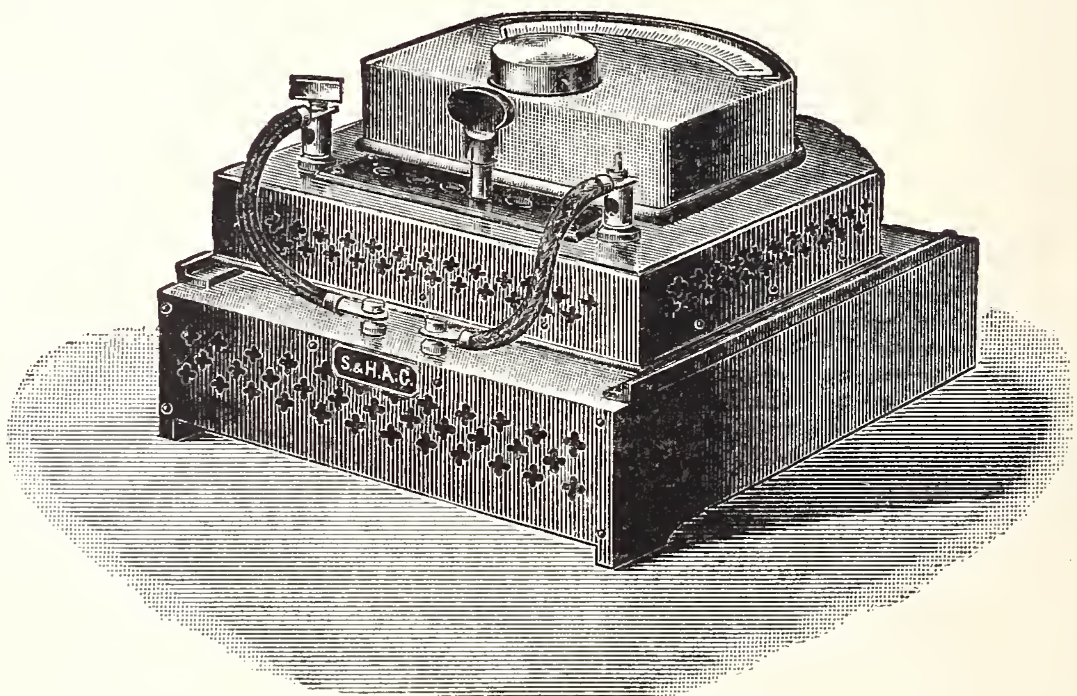


Fig. 21.

16. Precision Volt and Ampèremeter with six ranges, for continuous currents in laboratories, similar to No. 15. It measures within the following limits:—0.15, 1.5 and 15 ampères and 3, 15 and 150 volts. The plug supplied with the instrument first closes the circuit, but requires deeper insertion before the current passes through the instrument. Fig. 21.

Accessory:—1 Shunt of manganine for currents not exceeding 150 ampères, in a protecting case, which can be slid under the instrument.

17. Precision Voltmeter, a laboratory instrument with three ranges up to 15, 150 and 750 volts, respectively, for continuous currents. Similar to No. 15. Fig. 22.

18. Deprez-d'Arsonval Pointer Galvanometer, in a compact form with stop and movable scale so as to place the zero point accurately below the pointer, available as a sensitive bridge galvanoscope, a detector, &c. Its resistance is about 120 ohms and its sensitiveness amounts to about 1.5×10^{-5} ampères per division. Fig. 23.

19. Deprez-d'Arsonval Pocket Volt and Ampèremeter for 0 to 150 volts and 0 to 10 ampères, with four terminals and a key for putting the instrument into circuit, whilst the shunt remains permanently in the circuit. Similar to Fig. 23.

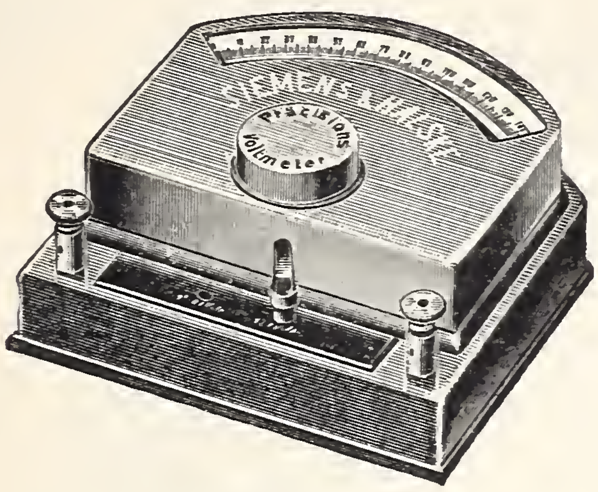


Fig. 22.

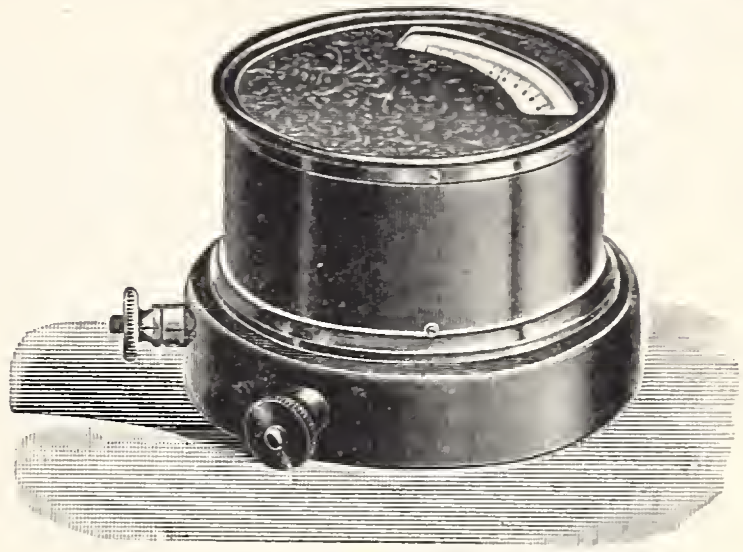


Fig. 23.

20. Deprez-d'Arsonval Pocket Ampèremeter, similar to No. 19, adapted for currents up to 50 ampères. With encased shunt for currents not exceeding 10 ampères, separate shunt for currents above 10 Ampères.

21. Deprez-d'Arsonval Pocket Voltmeter, similar to No. 19, with double range from 0 to 3 and 0 to 150 volts, for testing telegraph currents, cells, accumulators, &c.

22. Universal Current and P. D. Recorder, consisting of a very exact millivolt and ampèremeter (see No. 15) with uniformly divided scale and an electrically driven recorder, tracing every 3 seconds the position of the pointer upon a strip of paper advancing at the rate of 240 mm per hour. The apparatus may be driven by the main current if continuous and if the oscillations do not succeed ±10 per cent, otherwise four Hellesen dry cells, type No. 1, should be used for this purpose. Fig. 24.

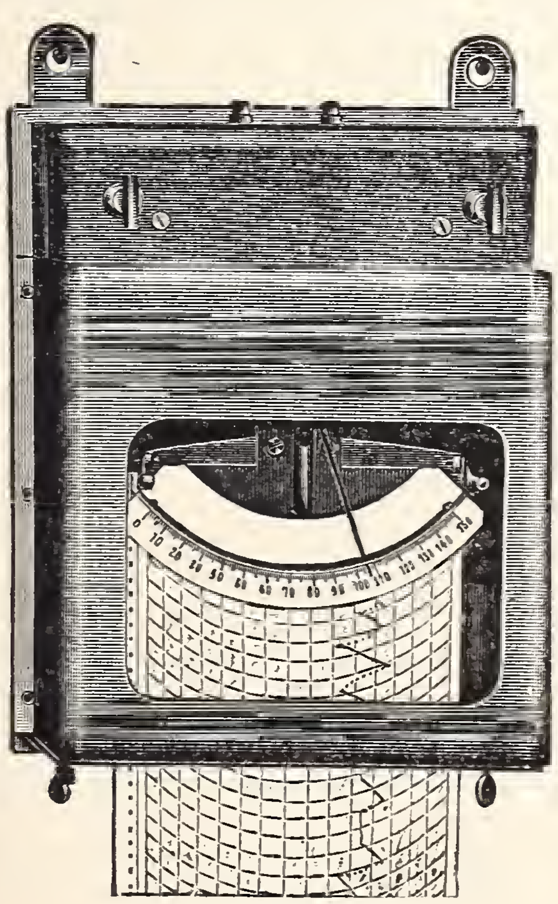


Fig. 24.

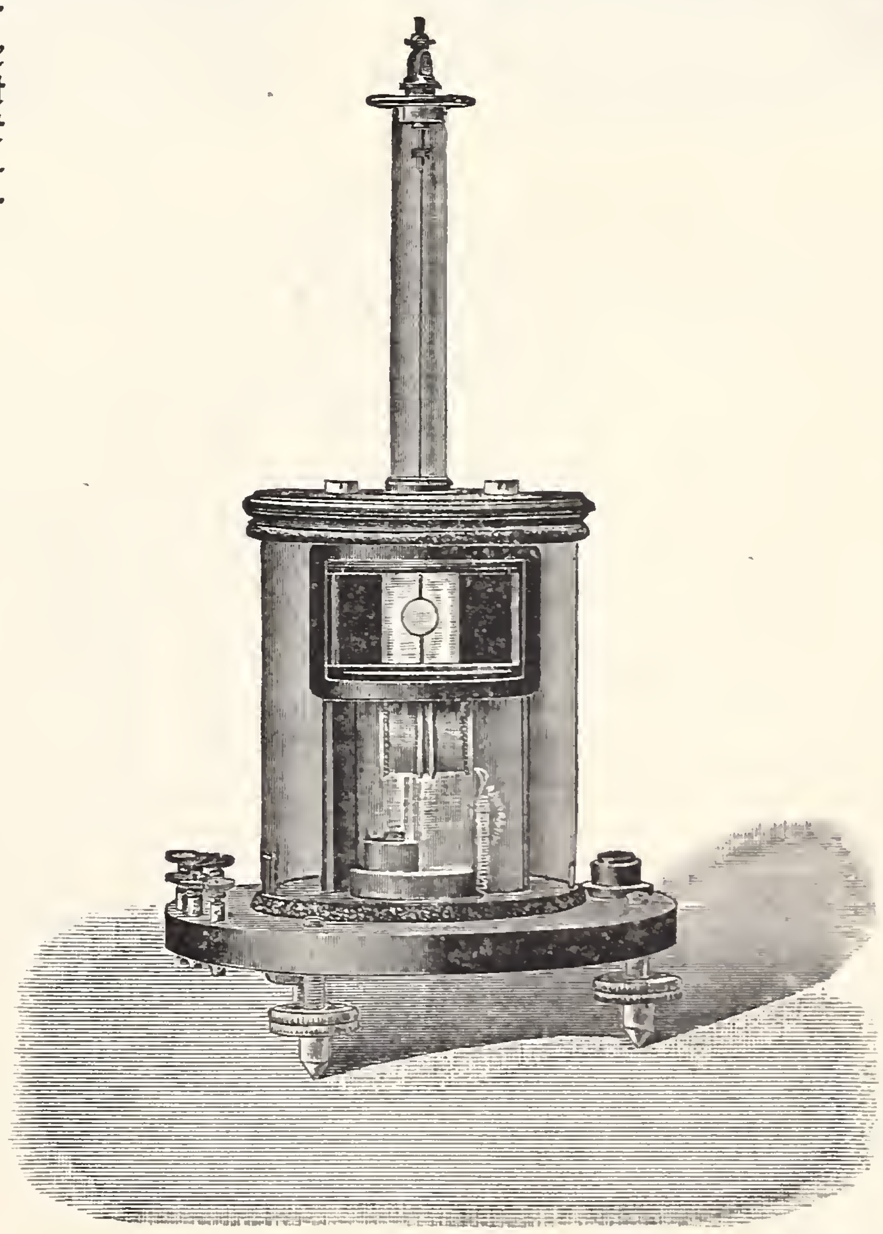


Fig. 25.

23. Reflecting Electro-dynamometer for weak currents with two stationary coils and a spherical movable coil without metal frame and fitted with pneumatic damper. The principal parts of the instrument are entirely free from metal and are made of insulating material; the instrument is therefore free from Foucault currents. Fig. 25.

24. Torsion Electro-dynamometer, or power meter, for continuous, alternating and rotary currents, perfectly free from Foucault currents, adapted for about 6 volts with two ranges of 0 to 50 and 0 to 100 ampères. Fig. 26.

Accessory: 1 Resistance coil free from induction with several sections for currents not exceeding 200 volts. Fig. 27.

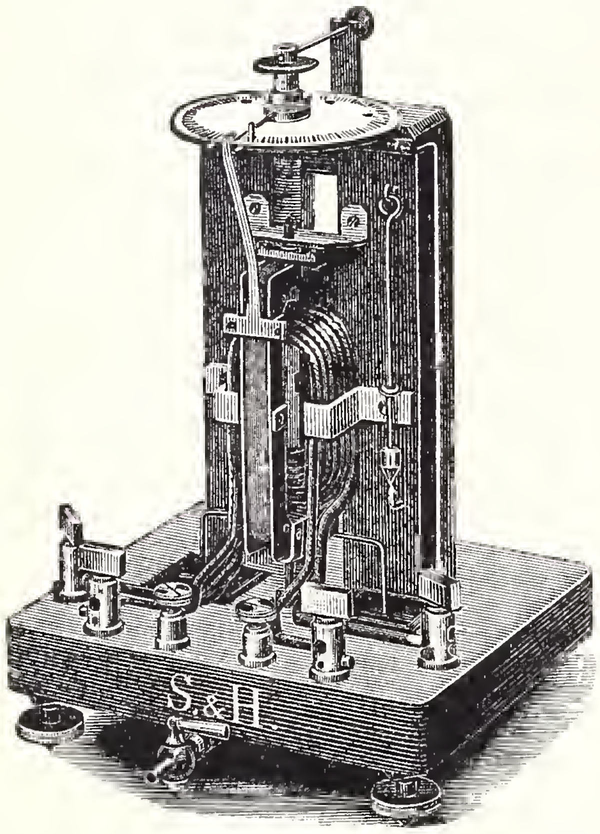


Fig. 26.

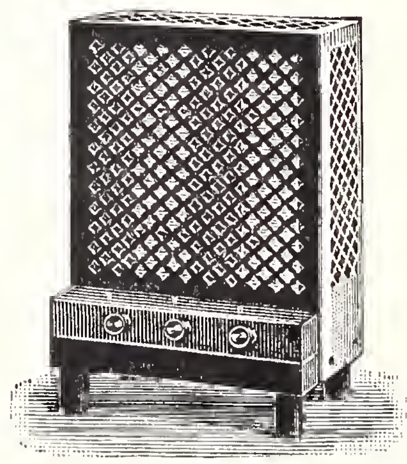


Fig. 27.

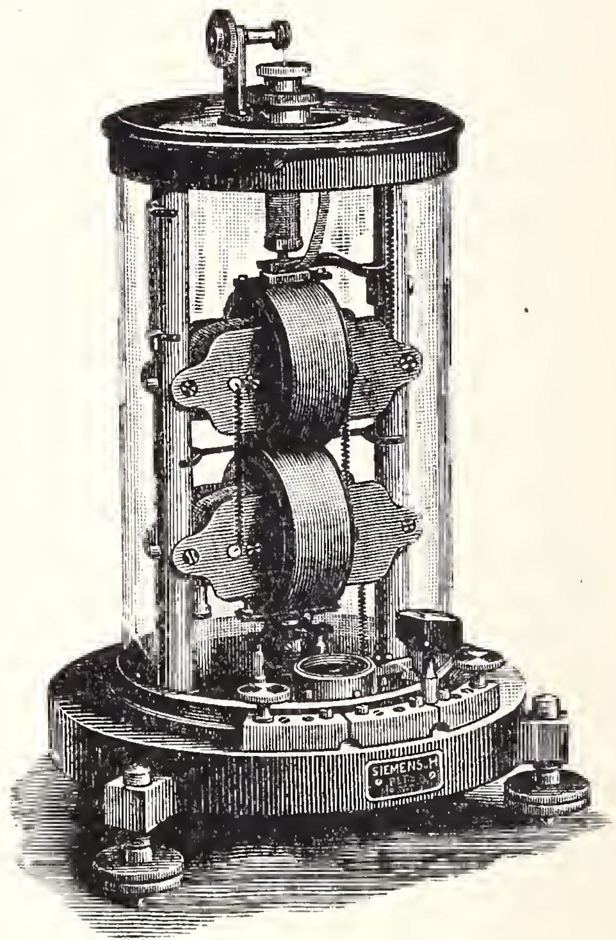


Fig. 28.

25. Astatic Torsion Electro-dynamometer for measuring the potentials of continuous and alternating currents of any periodicity and form of curve; available for two ranges of 120 to 360, and 240 to 720 volts. Fig. 28.

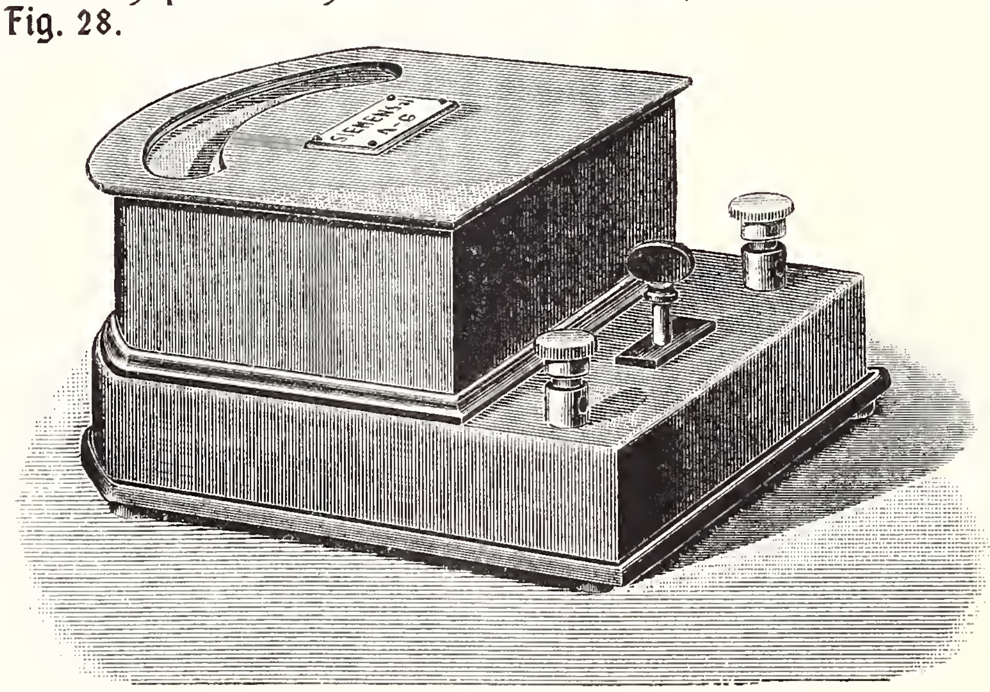


Fig. 29.

26. Precision Voltmeter for Continuous and Alternating Currents, a direct reading electrodynamic laboratory instrument with pneumatic damping and aperiodic adjustment, with two ranges up to 75 and 150 volts. The instrument is exact within 0.1 per cent of its nominal value and does not require any temperature correction. Its excellent insulation offers complete protection from the risks of high tension currents. Fig. 29.

27. **Wattmeter,** a direct reading laboratory instrument for measuring the power of continuous, alternating and rotary currents, with excellent pneumatic damping and aperiodic adjustment, free from Foucault currents, with two ranges for 12.5 and 25 ampères. The high power coil is so adjusted as to render the scale perfectly proportional and almost entirely eliminate the mutual inductive influence of the two coils in any position. The degree of exactness is within 0.1 per cent of the indications. Fig. 30.

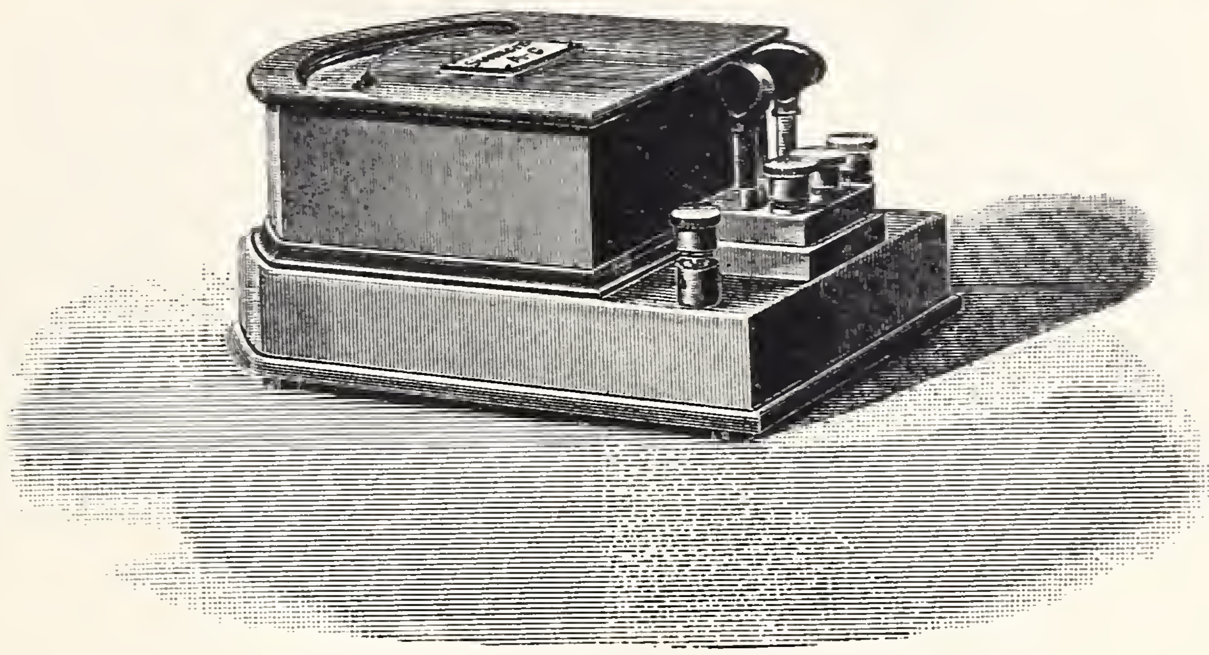


Fig. 30.

28. **Universal Resistance Box,** in mahogany box with ebonite top, for measurements by Wheatstone's bridge, consisting of plug resistances of 10,000 ohms in sections of 0.1 to 5,000 ohms and two shunts of 1, 10, 100, 1000 ohms, each, which may be connected by an infinity plug and by a resistance plug of 10 ohms. The resistance coils are bifilarly wound on metal and are perfectly free from induction, and are constant. Fig. 31.

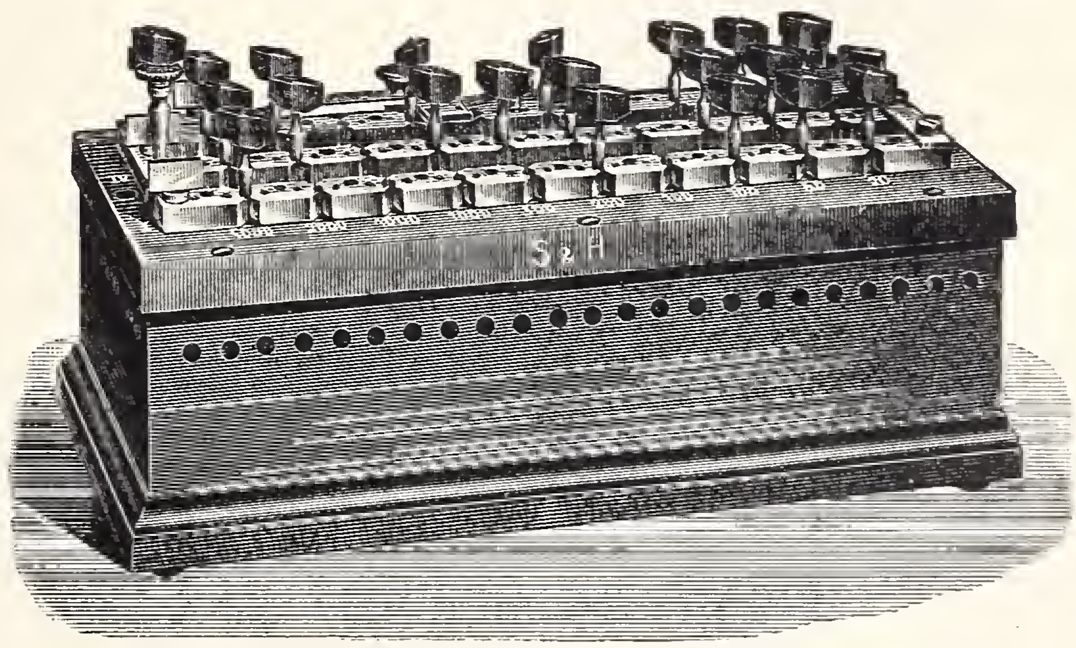


Fig. 31.

29. **Apparatus for measuring resistances** on mahogany board, compact and portable, for measuring without polarization within the limits of 0.01 to 1,000,000 ohms, for determining faults. Fig. 32.

30. **Telephon Bridge** for testing lightning conductors, consisting of a Wheatstone bridge, through which is passed the continuous current of two dry cells rendered intermittent by means of a contact wheel. The bridge together with a sliding contact, the contact wheel and two dry cells are fitted in a case with shoulder strap. Fig. 33. A comparison resistance coil of 10 ohms and the telephone are placed in a separate leather case.

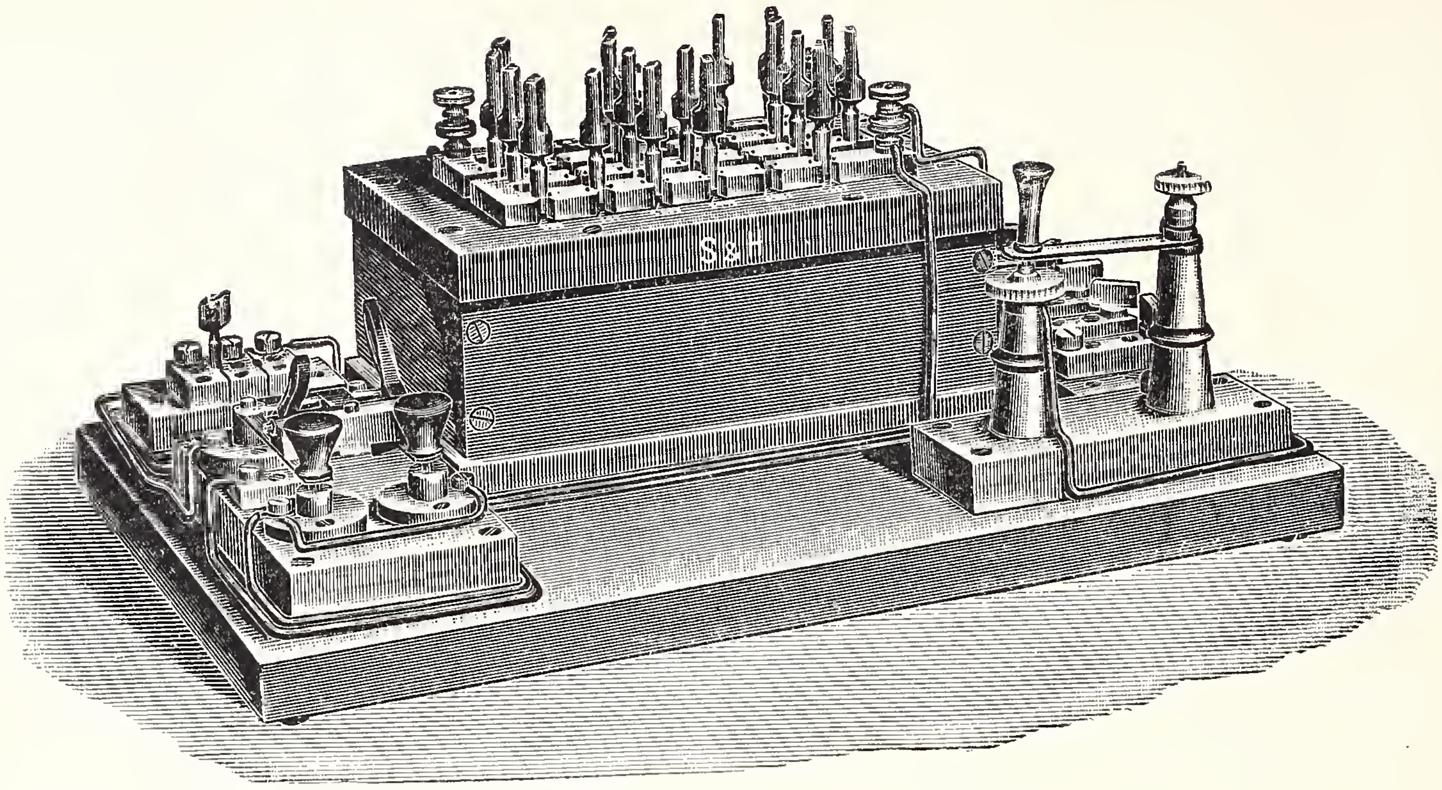


Fig. 32.

31. Apparatus for Comparing Standard Resistances with the aid of a Wheatstone or Thomson bridge, consisting of three petroleum baths separated by air strata, mercury cups for connecting the comparison resistances and shunts, a connecting rail and two turbines for agitating the petroleum worked by an electromotor (see No. 37). Fig. 34.

Accessories:—2 Resistance boxes of 2×10 ohms together with an interpolating resistance of 0.01 ohm (Fig. 2), and 2 standard resistances of 10 ohms (see No. 1).

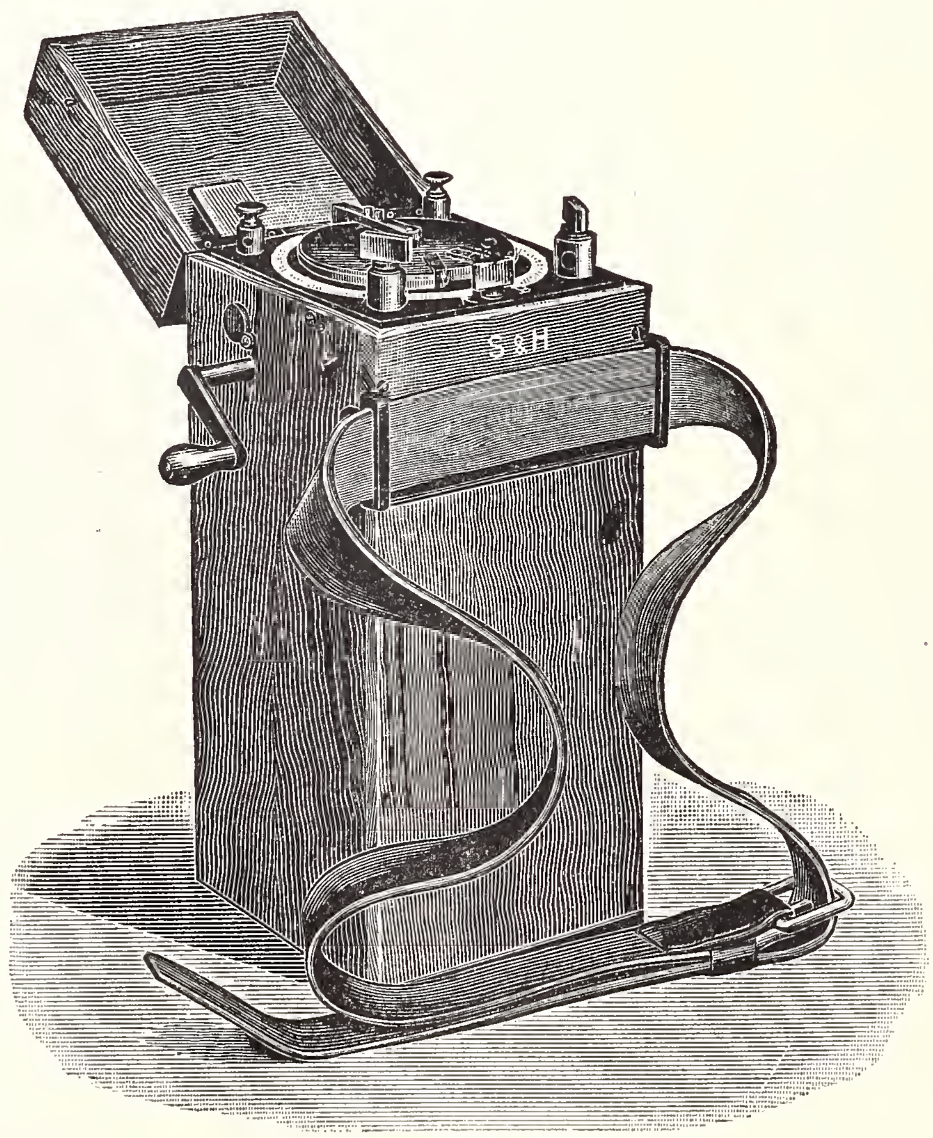


Fig 33.

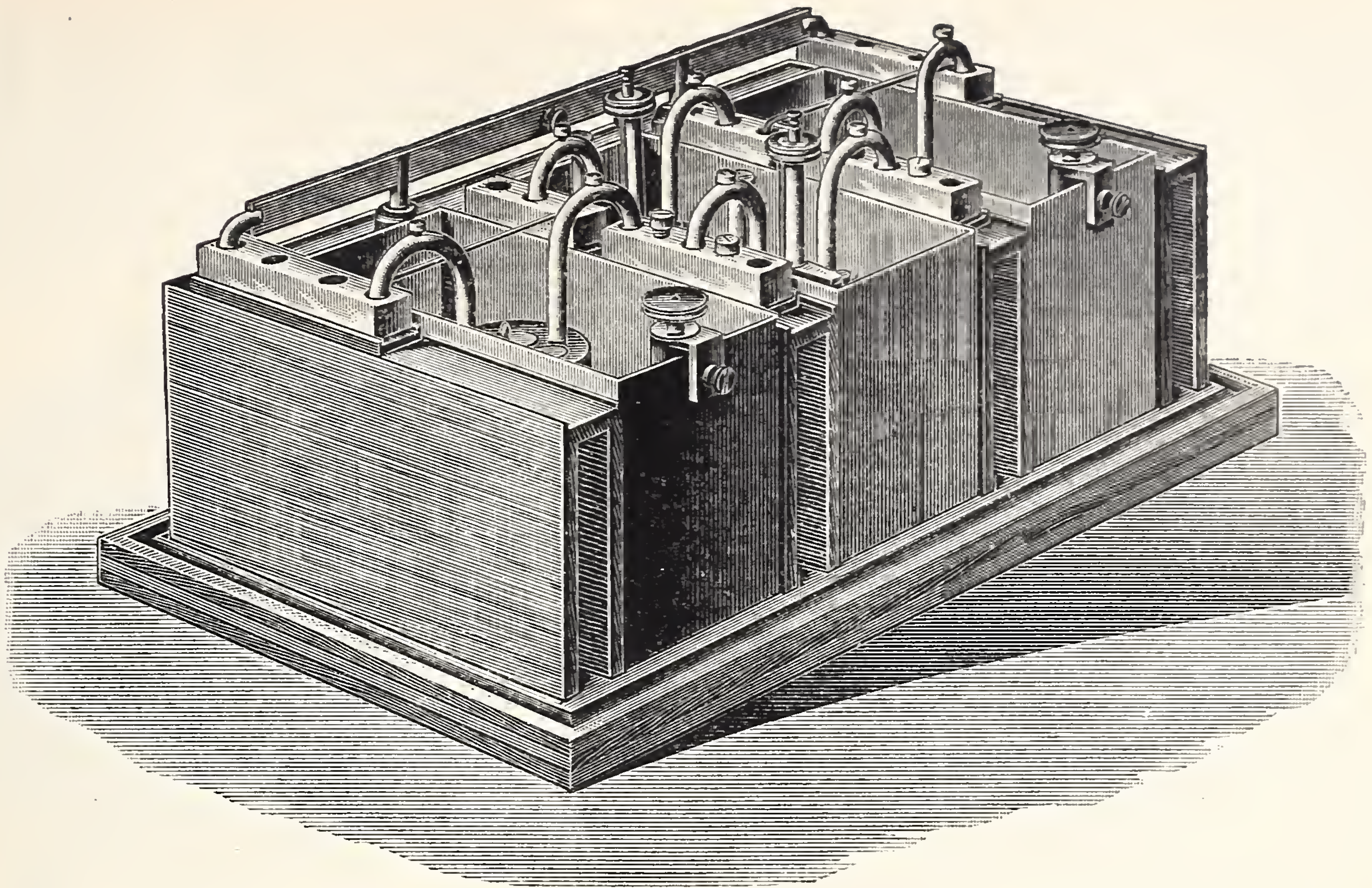


Fig. 34.

32. Apparatus for Measuring the Insulation and the Capacity, compactly arranged on a mahogany board, for testing the defects, resistances and insulation of cables, also for measuring the capacity by comparison with the charge of a mica condenser (see No. 8), with shunt for the Deprez-d'Arsonval reflecting galvanometer, so as to work with variable degrees of sensitiveness. Fig. 35.

The insulation of the cable is conveniently established in ohms by standardizing the reflecting galvanometer for resistance in connection with a shunt and a comparison resistance of 2×5,000 ohms mounted upon the board.

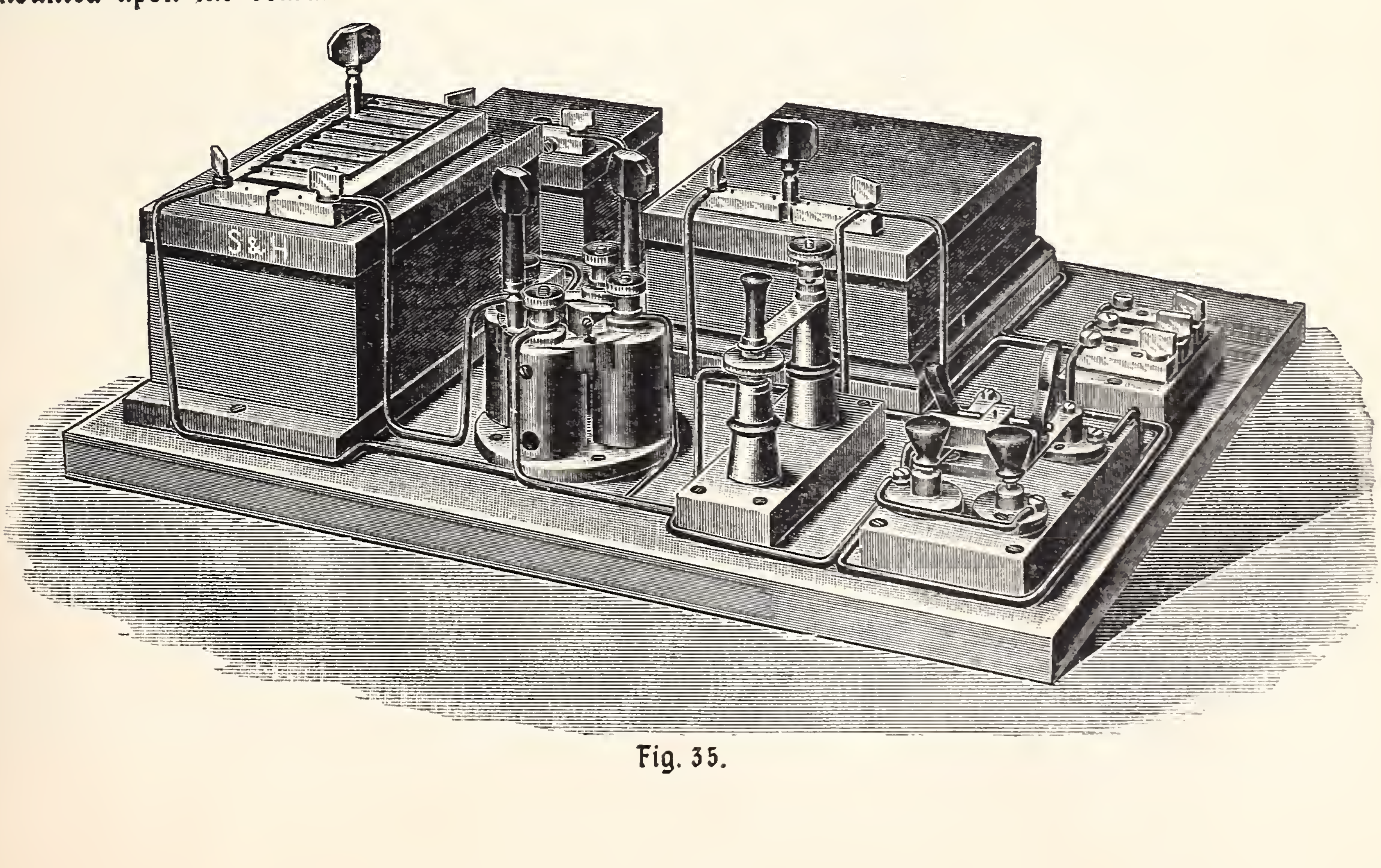


Fig. 35.

33. Precision Universal Galvanometer, compact and portable, for measuring currents, potentials, resistances and insulation, without restriction, with a degree of exactness sufficing for most technical and scientific purposes. Fig. 36. The diagrams mostly required for certain measurements are inscribed upon the cap of the instrument (as may be seen in Fig. 37). The apparatus is available for direct readings up to 0.15 ampère. Larger currents are measured with the aid of directly adaptable shunts in conjunction with the one-ohm milli-volt and ampèremeter. P. D. measurements can be made up to 150 volts, and resistances from 0.03 to about 30,000 ohms can be measured with the aid of a circular measuring wire by the Wheatstone bridge. With the aid of a battery of 110 volts insulating resistances can be measured up to 1,000,000 ohms.

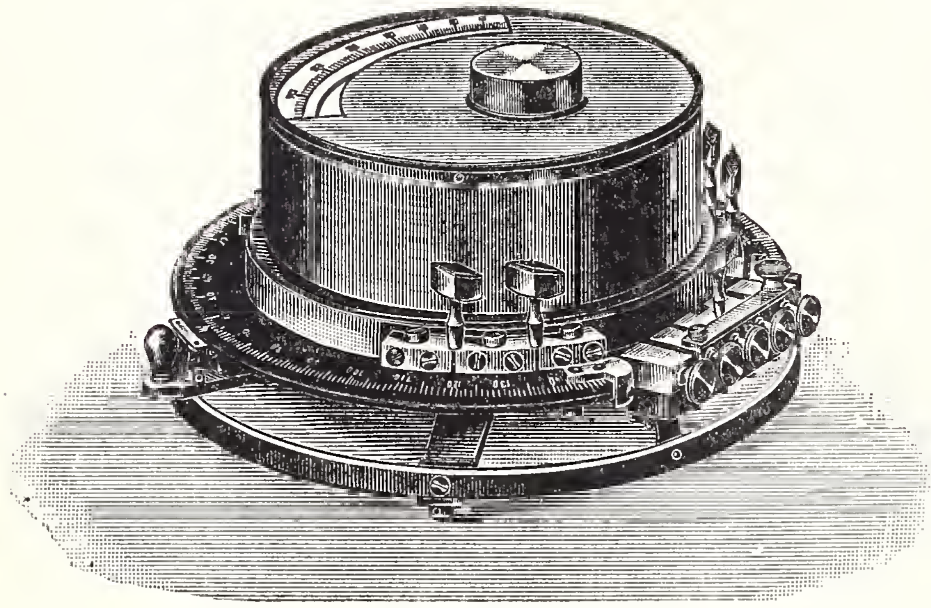


Fig. 36.

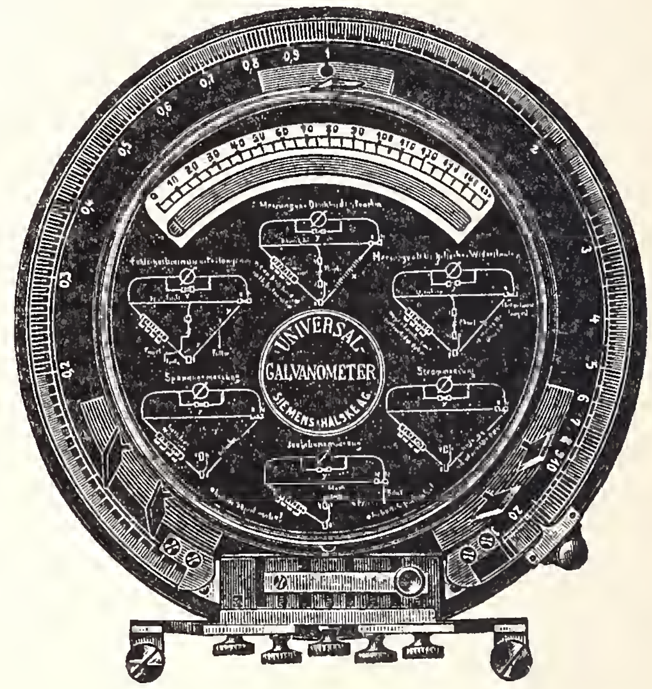


Fig. 37.

34. Du Bois' Magnetic Precision Balance for testing the magnetic properties of materials, with standard gauges for round and square rods, with spherical cheeks and all other necessary accessories. Fig. 38. The solenoids are placed directly round the rods and sheets which are subjected to the test

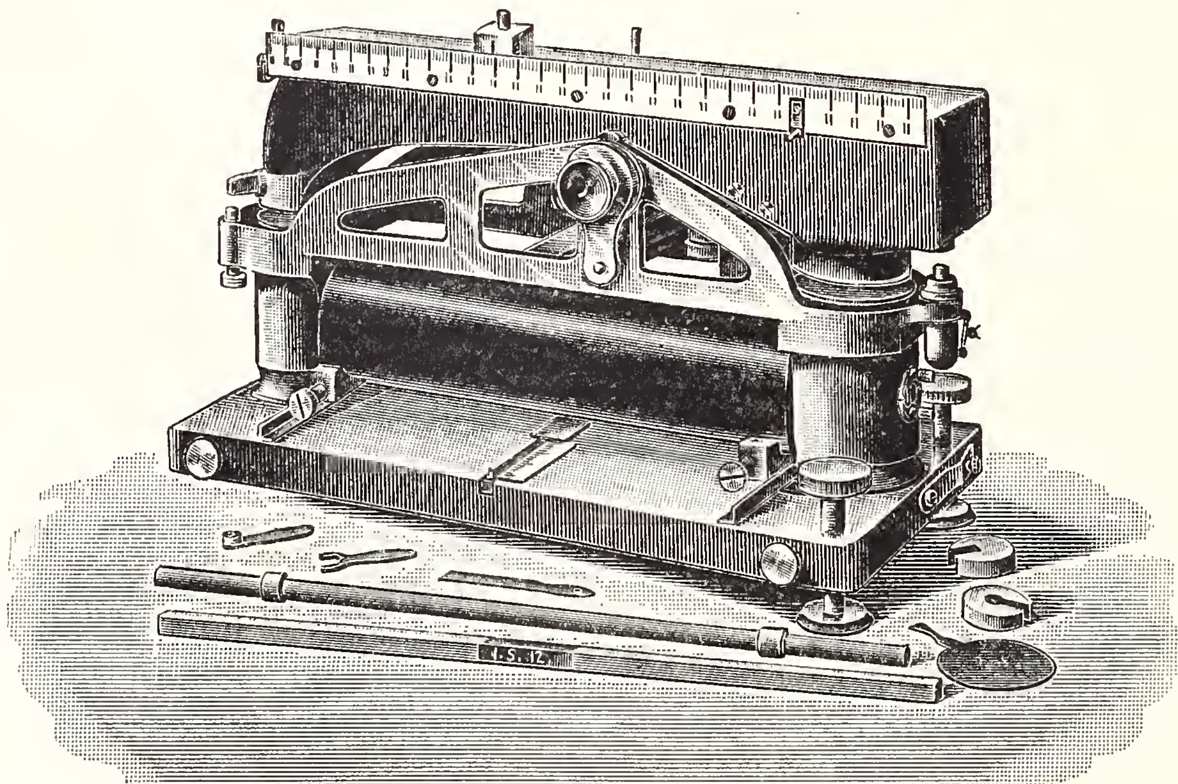


Fig. 38.

whilst a stout cross beam of cast steel of considerable permeability forms a dissymmetrical balance which is kept in equilibrium in opposition to the magnetic attraction produced by the magnetization of the whole system by means of a sliding weight. The magnitude of the displacement serves as a measure of the induction produced.

35. Köpsel's Apparatus for testing the Magnetic Properties of Iron and Steel in rods and sheet bundles of a given size, consisting of the magnetizing apparatus with dial giving direct readings of the magnetic induction per 1 sq cm, a one-crank resistance box, a three-crank resistance box and three Hellesen dry cells, type 2, all mounted on one board. Fig. 39.

The magnetizing current is supplied and measured by a 4 volt accumulator and a precision millivolt and ampèremeter having a resistance of 1 ohm (see No. 15).

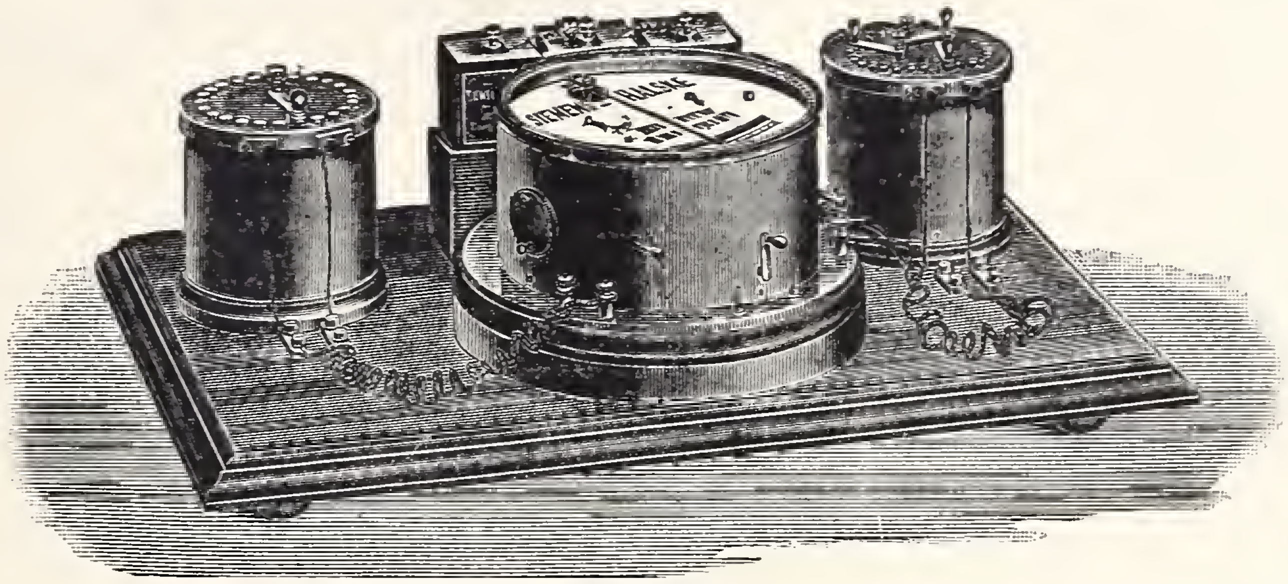


Fig. 39.

36. Large Reading Telescope for reflecting galvanometers, on tripod, with two reading devices for incandescent and gas light, vertically adjustable along the telescope stand. The telescope is fitted with rack and pinion and magnifies 30 times. Figs. 40 and 41.

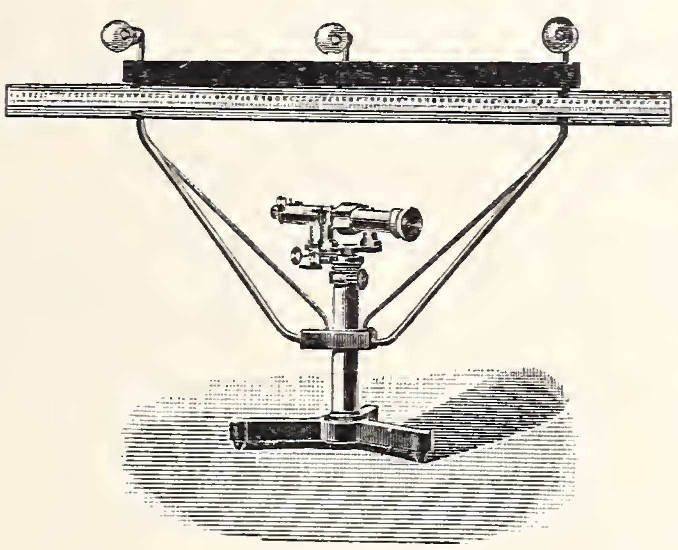


Fig. 40.

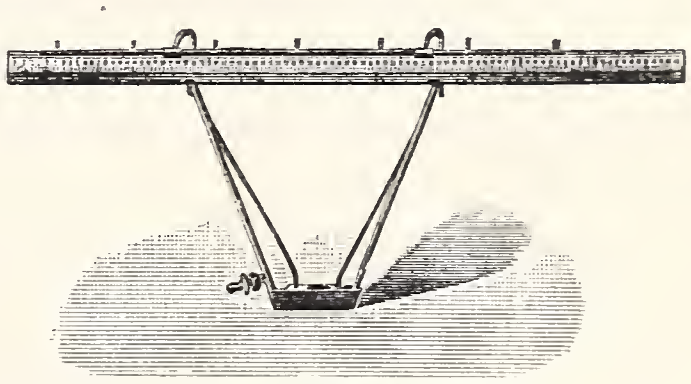


Fig. 41.

37. Small Electromotor for laboratory purposes, driving influence machines, rotating mirrors, stirring and shaking apparatus, &c., adapted to work with any desired voltage. Fig. 42.

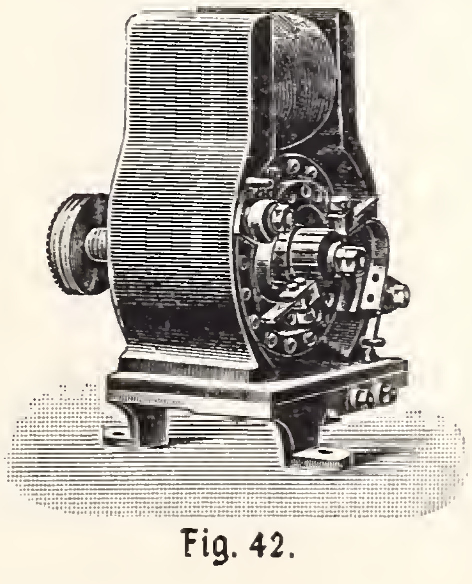


Fig. 42.

6. Heinr. Stieberitz (Otto Brunn Nachf.), Dresden.

1. **Hallwachs' Aperiodic and Non-magnetic Quadrant Electrometer.** The measuring force is supplied by the torsion of a fine platinum wire ($^1/_{30}$ mm thick), which is specially prepared so as to be free from elastic fatigue. Damping is effected by pneumatic friction. The apparatus can be adjusted with great precision with the aid of numerous orientating appliances.

Greatest sensitiveness: with "Doppelschaltung" (needle and one pair of quadrants together) 50 volts per 500 divisions of the scale; with "Quadrantschaltung" (usual arrangement) 1 volt per 150 divisions of the scale, the latter being 2 m distant.

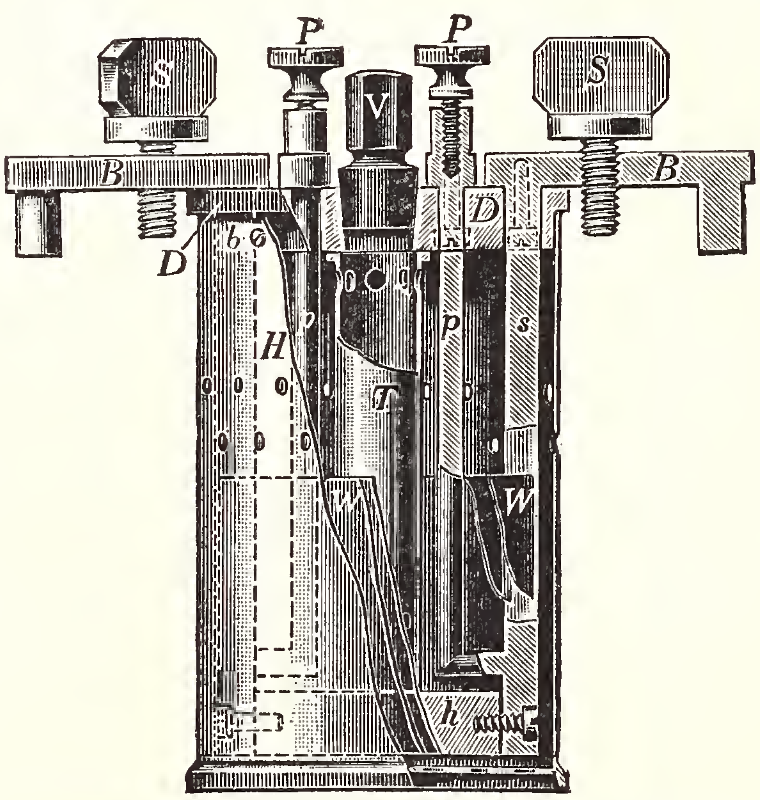
2. **Thomas's Curve-tracer for Alternating Currents.** This apparatus is designed for demonstrating the phenomena in alternating circuits. It consists of a drum with sensitized paper and driven by the spindle of a synchronic motor, upon which the light of an arc-lamp fed by a continuous current is made to fall through a condensing lens so as to trace upon the paper a curve representing the mean of 100 notations taken within two seconds at 100 reversals per second.

By suitably shunting the apparatus for different circuits, the same diagram may be employed for tracing current and voltage curves of monophase and polyphase currents, also for ascertaining the influence of capacity and self-induction upon the form of the current curve and for determining by single measurement the cosine of the phase displacement, &c.

3. **Stöckhardt's Instrument for Determining the Periodicity of Electric Currents.** This instrument consists of a tuning fork with movable weights fitted to the branches and a coil between their ends adjustable for a tone maximum by simply turning a milled head. The instrument is adapted for 100 volts and 80 to 100 reversals per second. The readings are taken direct from a scale along the course of the weights. The instrument is put into circuit like a voltmeter and is adapted for normal plants.

7. Otto Wolff, Berlin S.W., 14 Alexandrinenstr.

1. **Three Standard Resistance Coils,** new pattern, of 0.01, 0.001, 0.0001 ohm. This pattern possesses over the other forms the advantage that the main and shunt terminals consist of one solid piece of copper into which the ends of the resistance strips are brazed, whereas with the older



patterns the copper and the resistance strip ends brazed thereto had to be soldered both to the main terminals and the shunt clamps, the presence of the ebonite cover rendering brazing impossible. See Zeitschr. f. Instrumentenk. 18. p. 19. 1898.

2. Petroleum-bath for Standard Resistances. An accessory for use with the standard resistances when measuring currents. A turbine causes the petroleum, which is heated by the passage of the current, to flow round an annular vessel kept cool by the circulation of cold water and thereby cools the resistances.

3. Wheatstone Bridge with Plug Connection. The bridge contains five pairs of ratios of 1,000, 100, 10, 1, 0.1 ohms and a set of resistances of 50,000 to 0.1 ohm, 111,111 ohms in the aggregate, and is fitted with stout terminals for the resistances under examination and also with battery and galvanometer key for permanent and instantaneous connection. When not in use, the apparatus is protected from dust and light by a closely fitting wooden cover. As the terminals project from the sides of the bridge the cover can be placed over the bridge without removing the wire connections.

4. Wheatstone Bridge with Sliding Contacts. This bridge contains four pairs of ratios of 10,000, 1,000, 100, 10 ohms with plug connection and three interpolating resistances of 1, 0.1, 0.01 ohm, which, by means of plugs, may be added to either side of the arms, also a commutator for reversing the two arms, two terminals for the resistances under examination and battery and galvanometer keys for permanent and instantaneous contact. The resistances consist of six decades of 10,000, 1,000, 100, 10, 1, 0.1 ohm and are of the sliding contact type. The sliding contacts consist of a large number of thin metal leaves brushing over the contacts. A wooden cover is provided for protection from dust as with the preceding apparatus.

VII. Electro-medical, Physiological and Biological Instruments.

1. W. A. Hirschmann, Berlin N., 14/15 Johannisstr.

Maker of Electro-therapeutical Instruments.

1. **Stationary Universal Apparatus for Galvanic and Faradic Currents,** in conjunction with an influence machine. Fig. 1.

2. **Stationary Apparatus for Galvanic and Faradic Currents,** simple arrangement adapted for connection to continuous circuit of 110 volts. Fig. 2. Such stationary apparatus is adapted for use with accumulators and primary cells, or may be directly connected with street mains carrying a continuous current. The auxiliary appliances satisfy all therapeutic and diagnostic requirements. In designing the apparatus considerable attention has been paid to the convenience in manipulation.

3. **Portable Apparatus for Constant and Induced Currents.** This apparatus is fitted with galvanometers for absolute measurements. They are partly fitted with resistance coils for regulating the current, and all are provided with cell counters for putting any number of cells singly into circuit. The size of the cells is chosen according to the strength of the current, which in its turn depends upon the purpose for which the apparatus is required. The portable induction apparatus is fitted with one or two cells according to the frequency with which it is intended to be used. Those arranged for clinical use, in particular, are provided with Leclanché cells.

4. **Auxiliary Appliances for Electro-therapeutical Purposes and for Electrolysis.** Galvanometers, Rheostats, Electrodes of various forms, Handles for electrodes fitted with interrupters, Needles for electrolysis, Sounds, &c.

5. **Portable Accumulators for Illumination and Cauterisation.** These accumulators are so designed as to render them adapted for irregular medicinal use. They are charged with solid filling and all connections are protected from oxidation. Self-discharge is effectively obviated, even with very occasional use. The entire arrangement is such that the accumulator may conveniently be carried and shipped. The size of the accumulators depends upon the nature of the instruments used.

6. **Cautery Instruments.** Burner handles and galvanocaustic loops. Burners of various sizes. Dr. A. Mackenrodt's Set of instruments for gynaecological operations.

7. **Prof. Bottini's Set of Instruments for Galvano-cautery of Prostata-hypertrophy.** Fig. 3. This set consists of a table travelling on casters and carrying an accumulator and ampèremeter. The accumulators suffice for a considerable number of operations and are also available for illuminating instruments. The galvano-caustic burners are so constructed as to allow of the cutting surfaces being moved with great precision, and perfect cooling is provided for.

8. **Illuminating Instruments.** Head-lamps of various forms. Instruments for the translumination of the cavity of the upper jaw, for the translumination and illumination of the stomach, urethroscopes, rectoscopes and oesophagoscopes, &c.

9. **Cystoscopic Instruments.** Figs. 4 and 5. Dr. M. Nitze's Simple Cystoscopes corresponding in size to catheter Nos. 21, 18 and 15. Dr. Casper's Catheter-cystoscopes for intravesical operations. These cystoscopes are provided with good optical fittings, they have a large field and an incandescent lamp yielding perfect illumination. The instruments are fitted up in such a manner that they can be

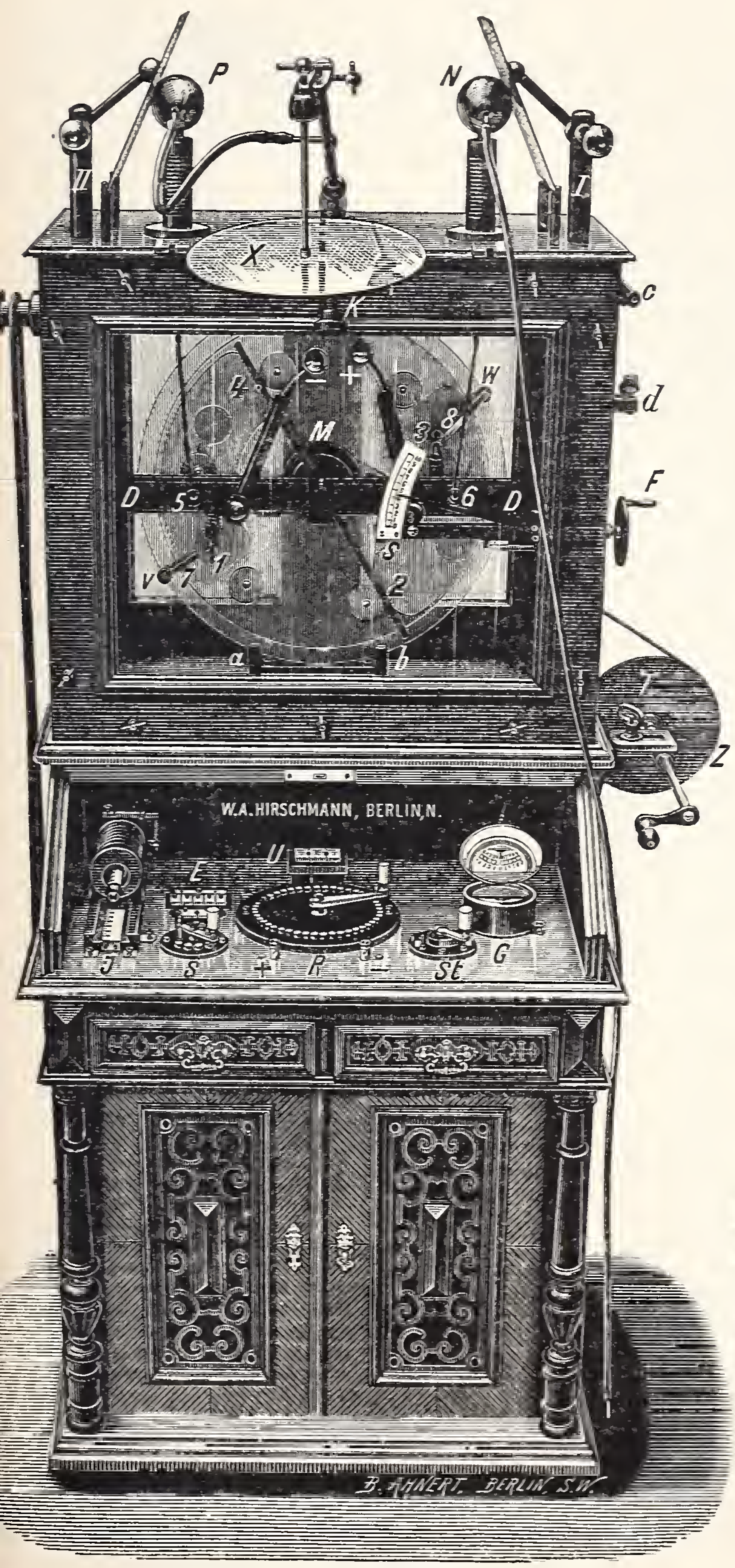


Fig. 1.

Fig. 2.

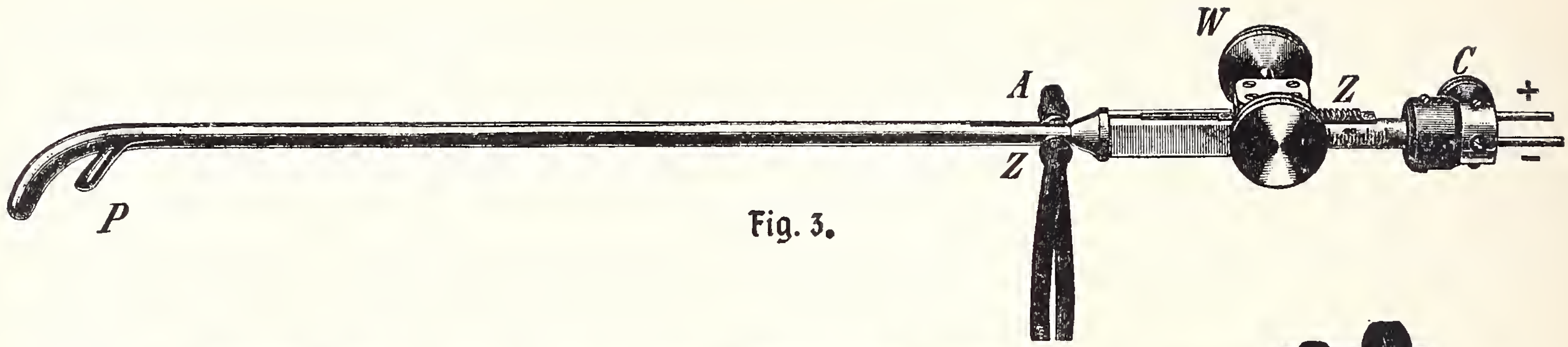


Fig. 3.

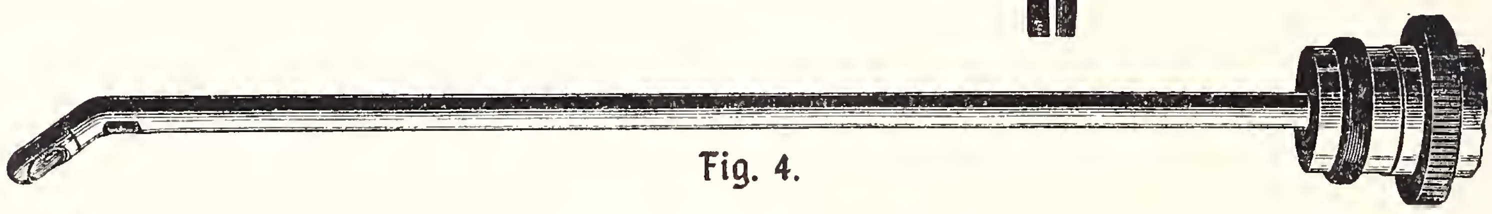


Fig. 4.

Fig. 5.

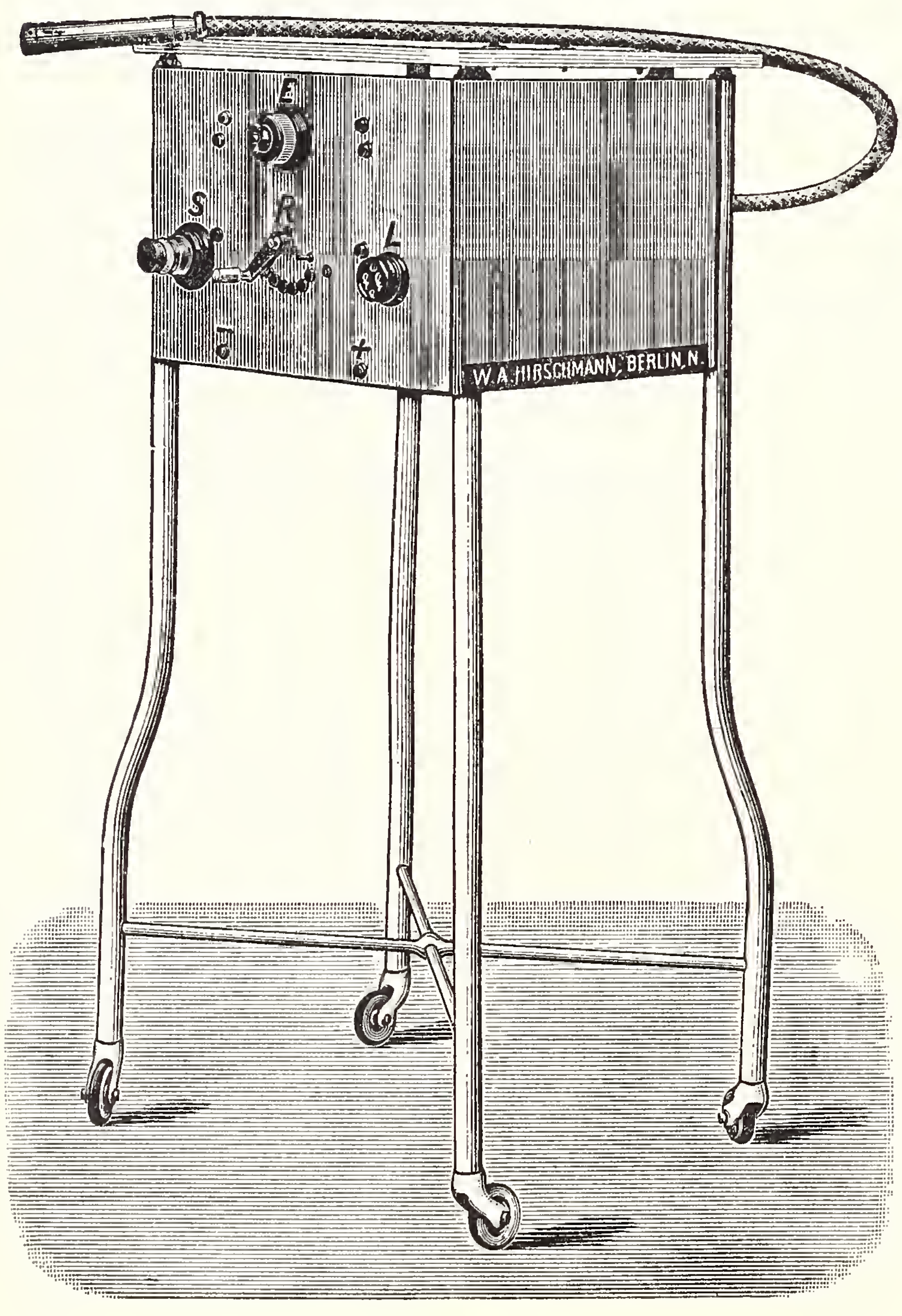


Fig. 6.

thoroughly cleaned by entire immersion in sterilizing fluid without risk of damage to the optical and electrical fittings. Cystoscopes intended for the catheterization of the urethra are so constructed that the catheters can be easily passed in and directed after their introduction. Cystoscopes constructed for operations are fitted so as to be available for various different instruments; the instruments are therefore interchangeable and may be used independently of the cystoscope. The forceps-like instruments are constructed after the pattern of lithotriptors, whilst in another form branches are provided opening laterally and so arranged that the field of operation and the instruments can be seen concurrently.

10. Appliances for Illuminating Instruments, available for connection with a direct current plant.

11. Universal Apparatus for Galvanic Cauterisation and Illumination adapted for connection with a continuous circuit; transformers for cautery and illumination, for connection with an alternating circuit. The whole of the models are adapted for use with street installations and so arranged that they may be connected directly with the main. The regulation of the strength of the current, as required for small illuminating instruments, is effected in the same manner which is usually adopted in the case of accumulators and other sources of electricity. The instru-

ments are used in the usual manner. The apparatus for use with galvanic and faradic currents, intended for direct connection, do not differ in their general form from the stationary apparatus specified under No. 2.

12. Outfit for Vibratory Massage. The electromotors available for massage are adapted to work with accumulators and for direct connection to an electric light installation and are designed for continued and sufficiently powerful working. Rapid and vigorous vibrations are produced by excentric rotation of a suitably shaped weight, and these vibrations are transferred to flat and button-shaped applicators.

13. Prof. von Bergmann's Instrumental Outfit for Operative Purposes. Fig. 6. The ½ H. P. motor suffices for major operations and is mounted under a table travelling on casters. The rotation is transferred to the instruments by means of a flexible shaft. The whole design is such that the apparatus may be used in any operating room and cleaned like any other set of instruments. The instruments are in particular available for trephining work and strongly made so as to bear the power supplied by the motor.

14. Instrumental Outfit for Operations of the Nose and Ear. The electromotors are fitted with a flexible shaft so as to transfer its rotation to the instruments. The latter consist of various sizes and forms of écraseurs for operations of the mastoid process, for opening the cavity of the upper jaw, circular saws, drills, &c. The electromotors are also available for use with the massage instruments.

15. Instrumental Outfit for Producing and Applying Röntgen Rays for medicinal purposes. Fig. 7. The whole is a complete outfit satisfying the requirements of hospitals and

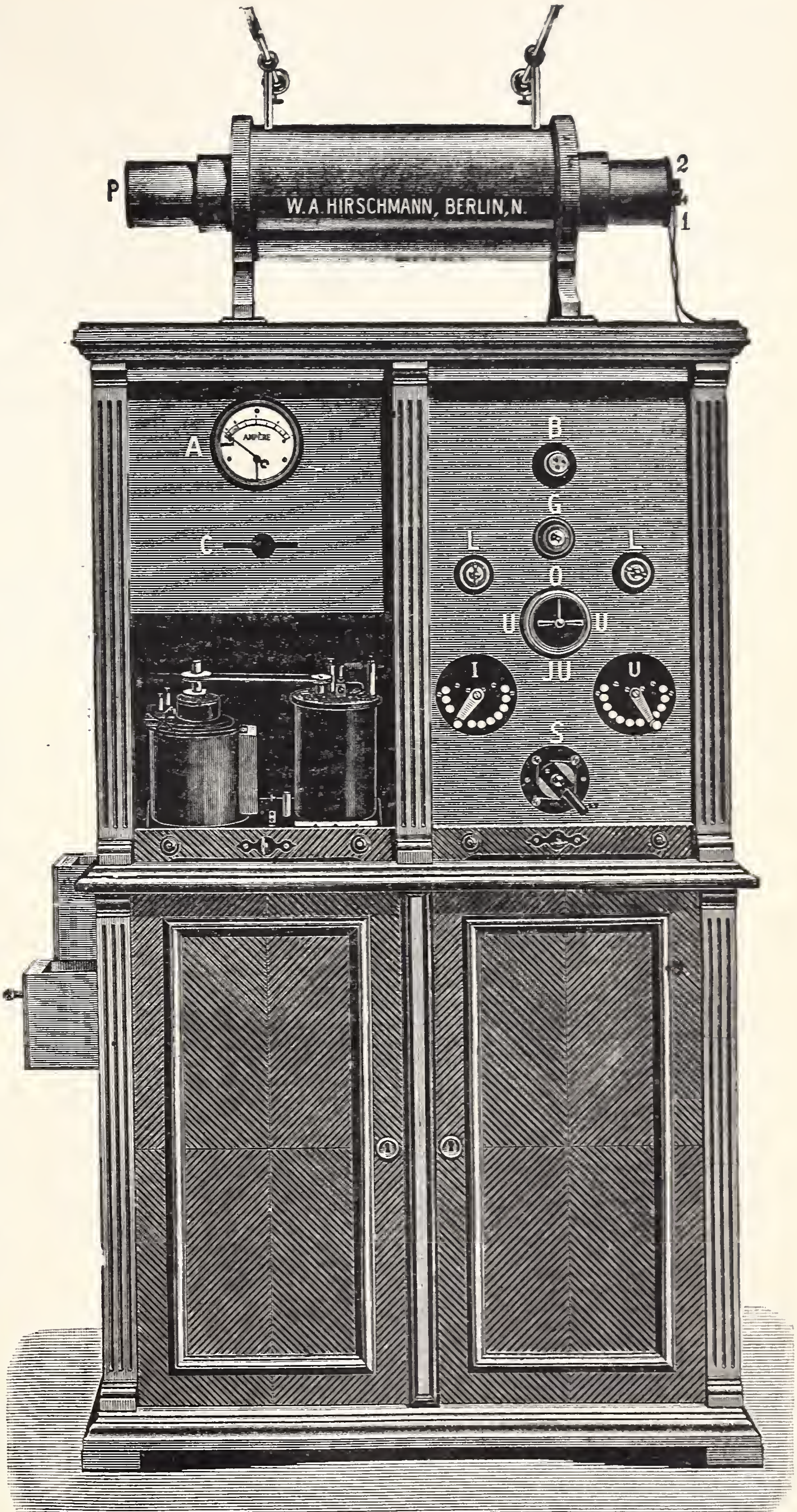


Fig. 7.

clinics. The specification includes an induction-coil yielding a spark of 50 cm, the requisite resistance coils for connection to street installations and a mercury interrupter capable of yielding 6,000 breaks per minute. The number of breaks may be increased, if desired; this is however not necessary with the appliances occurring in practical use. The whole of the resistances required for the adjustment of the strength of the current are connected with the apparatus. The whole outfit is so arranged as to join on to the street main without special connections. The whole, being compactly arranged, is very simple in actual use and reliable. An electrolytic interrupter can be used with this apparatus, which is fitted with the necessary connections.

16. **Spark Induction Coils** yielding sparks 50, 40 and 30 cm long. These coils are all adapted for high voltages and accordingly available for connection to continuous currents of 220 and 110 volts, they may however also be worked by accumulators. The interrupters and commutators do not form part of the coils, as it is more convenient to connect them with the other appliances.

17. **Auxiliary Apparatus for Spark Induction Coils.** Rotatory interrupters of various forms, electrolytic interrupters, Röntgen tubes of various sizes, photographic auxiliaries, translumination screens, &c. The rotatory mercury interrupter is adapted for working by accumulators and for connection to continnous circuits, it is therefore adapted for any Röntgen installation. No separate source of electricity is required for the interrupter, which is worked by the same current as the coil itself. When using the interrupters with accumulators the frequency of the vibrations should be rather less. The contacts are subjected to very little wear and the circuit is always closed completely and with perfect regularity.

18. **Apparatus for the Use of High Tension Alternating Currents** after Tesla, d'Arsonval. These appliances are used in conjunction with spark coils, which are suitably worked by mercury interrupters but are also available for use with platinum interrupters.

2. R. Jung, Heidelberg, 12 Landhausstr.

(See also Section Vc.)

1. **Förster's Perimeter,** considerably improved, on metal foot, with reliable moving mechanism and revolver for five colours and four square sectors. Fig. 1.

2. **Priestley-Smith's Perimeter,** latest form. Fig. 2.

3. **Registering Perimeter,** new form.

4. **Förster's Visiometer,** with new diaphragm movement.

5. **Priestley-Smith's Ophthalmological Hand-lamp,** Leber's improved modification.

6. **Rindfleisch's Skiascope.**

7. **Weiss's Exophthalmometer.**

8. **Fick's Ophthalmotonometer,** with Koster's reticule.

9. **Weiss's Demonstration-plate,** with four diagrams.

10. **Thoma's Plate** for the microscopic demonstration of the circulation of blood in the mesentery and omentum of dogs and rabbits.

11. **Thoma's Frog-plate** for the microscopic demonstration of the circulation of blood in the mesentery.

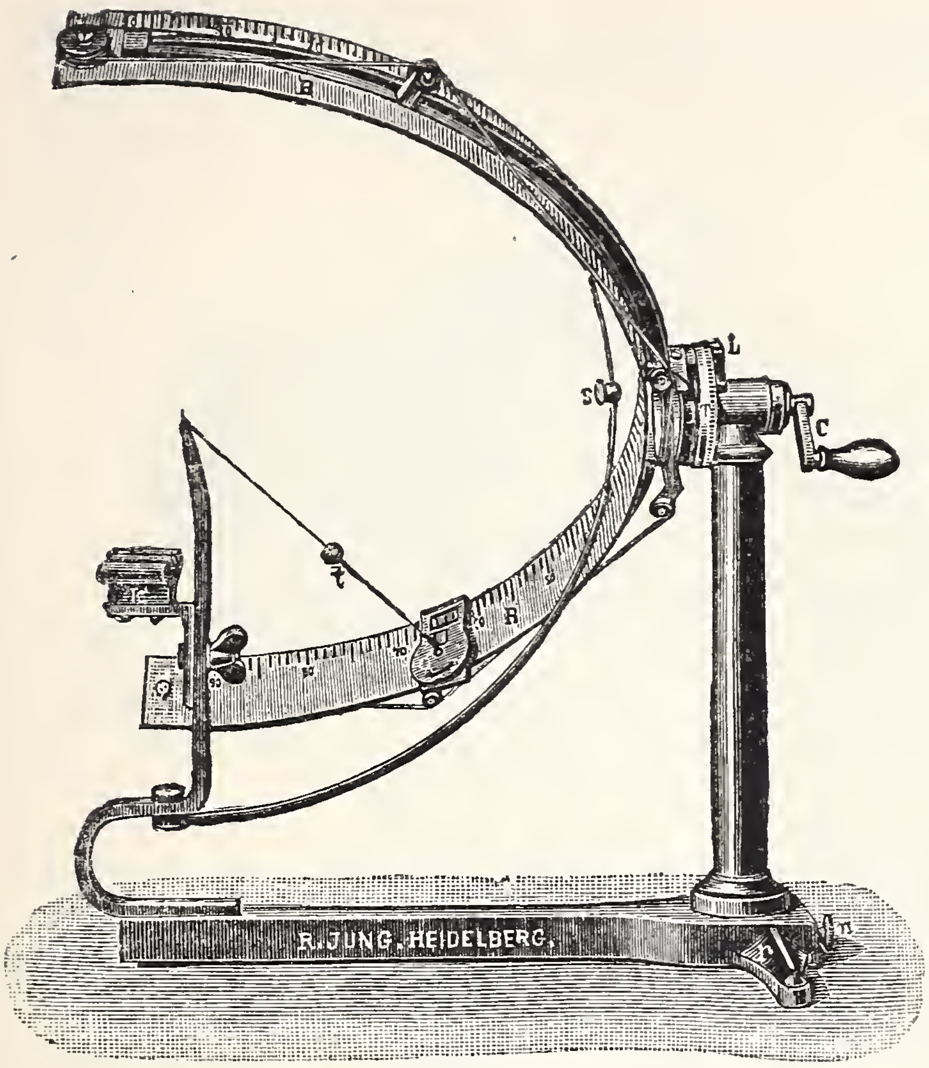


Fig. 1.

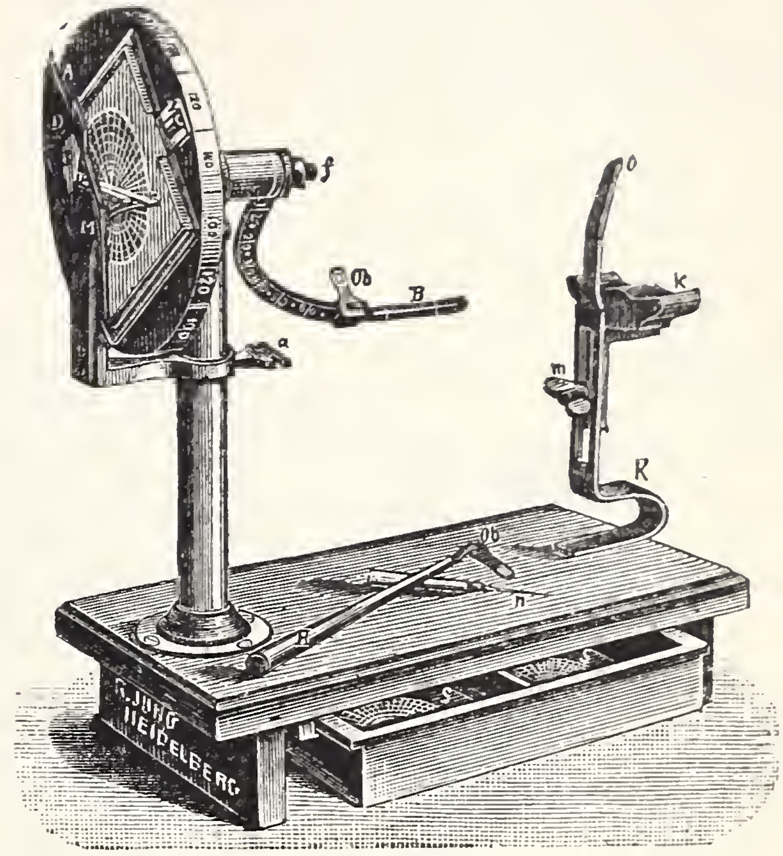


Fig. 2.

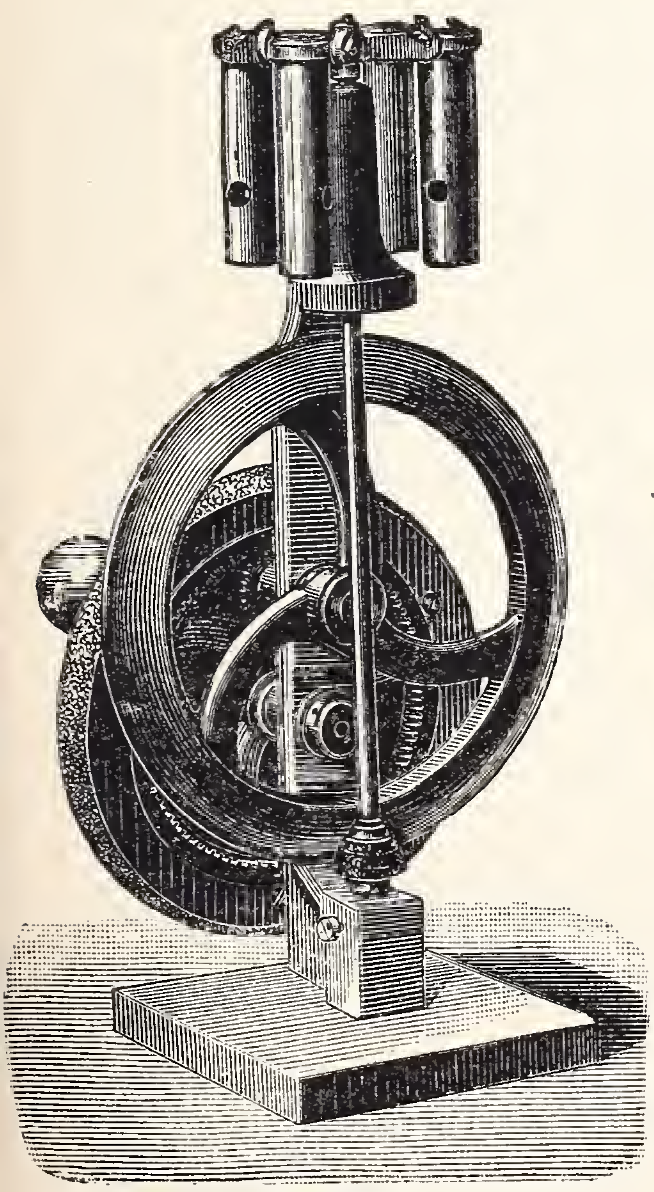


Fig. 3.

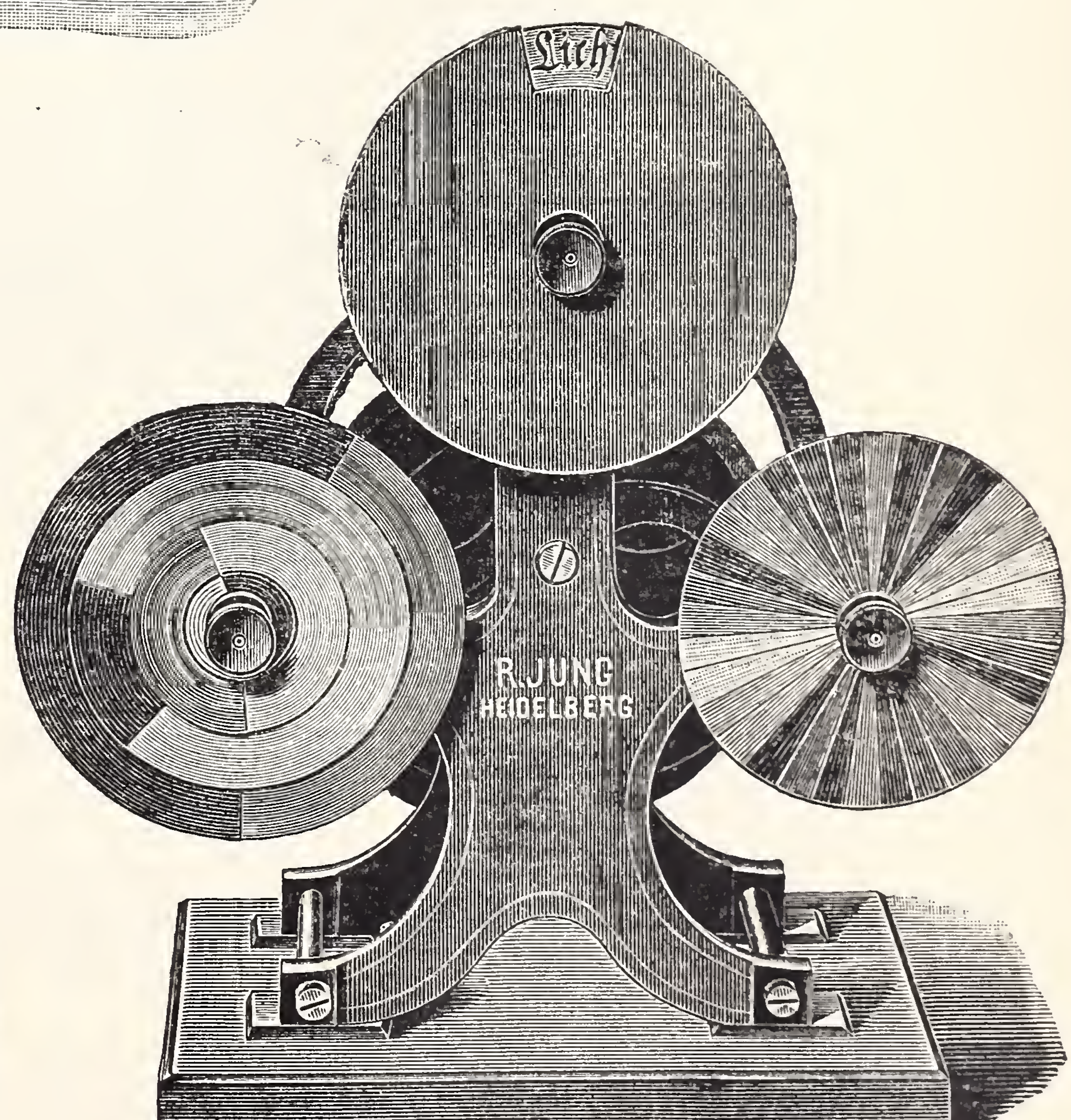


Fig. 4.

12. Hand Centrifuge, working at 4,000 to 6,000 revolutions per minute, with covered gearing and guard over the four cylinders of about 40 ccm capacity each. Fig. 3.

13. Rotating Apparatus for one large or three small coloured disks. Speed 4,000 to 6,000 revolutions per minute. Fig. 4.

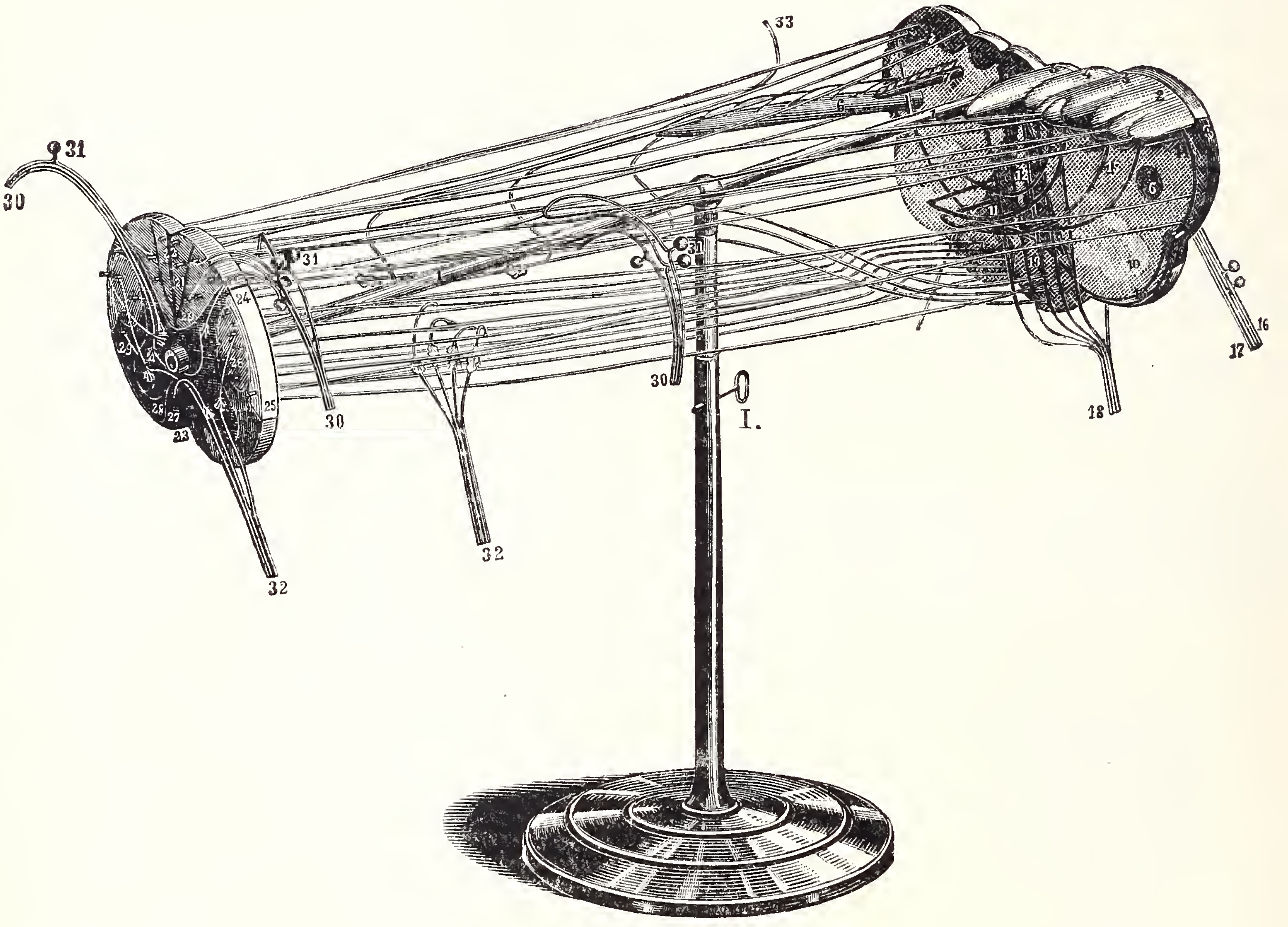


Fig. 5.

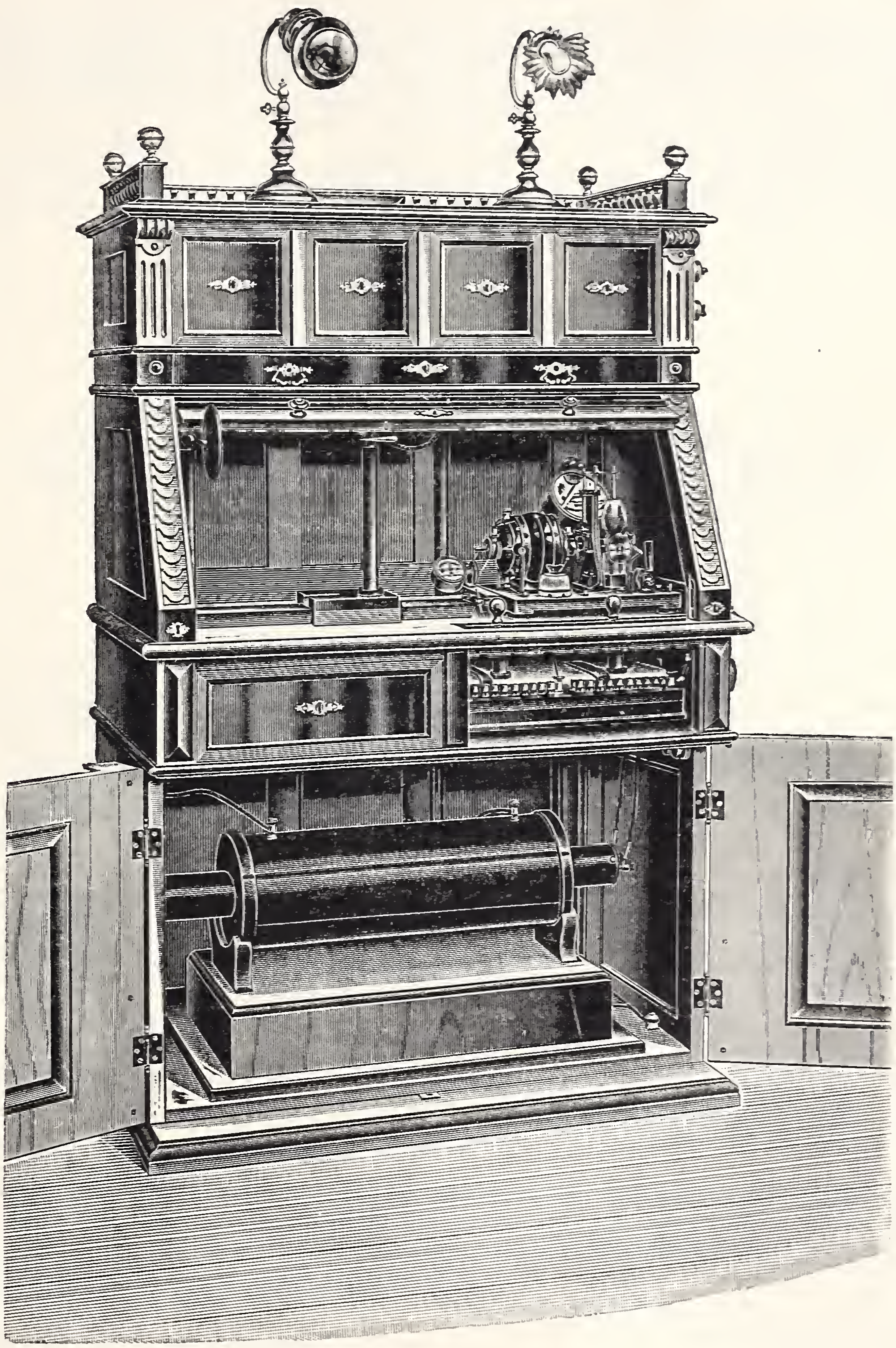
14. Edinger's Model of the upper spinal cord and the medulla oblongata. This model shows the structure of the organs magnified 25 times and is closely based upon the 5th edition of Edinger's "Twelve Lectures on the structure of the central nervous organs." Fig. 5.

3. Max Kohl, Chemnitz (Saxony).

(See also Section VIII.)

Röntgen Desk Cabinet. The intermediate portion of this cabinet contains a rotating interrupter, an ampèremeter and a spark stand upon a white marble slab. A stout framed pane of plate glass slides into the upper part, while the cabinet is open, and constitutes the cover of this section. The upper section is fitted with four drawers lined with felt for Röntgen tubes and a flat drawer

for a luminous screen having a surface of 30×40 cm. Below the table top the cabinet contains on the right two current regulators for the induction coil and the rotating interrupter respectively. Regulation is effected by means of two sliding buttons situated above the table top. On the left



side the cabinet is fitted with a drawer for conducting wires, an oil-can, &c. The lower cup-board contains the induction-coil. The cabinet is surmounted by elegantly fitted incandescent lamps, one being white, the other red. Their switches are situated on the right side of the cabinet.

4. Wilh. Petzold, Leipzig-KZ., 6 Schönauerweg.

Physiological Instrument Maker.

Ludwig's Kymograph with rollers for endless paper. The general form of Ludwig's design is retained, but the following modifications have been introduced:—From Fig. 1 it will be seen that the fixed angularity of the cylinder frame has been replaced by an adjustable frame of two parts, one of which is fixed, while the other, or upper part, can be rotated about the main driving spindle without in any way obstructing its movements.

This part has firmly attached to it the frame which carries the cylinder, the apparatus for automatically raising and lowering the latter and a friction wheel. The lower, or fixed, angle disk has five notches cut in its circumference. The upper part is fitted with a lever and pawl fitting these notches.

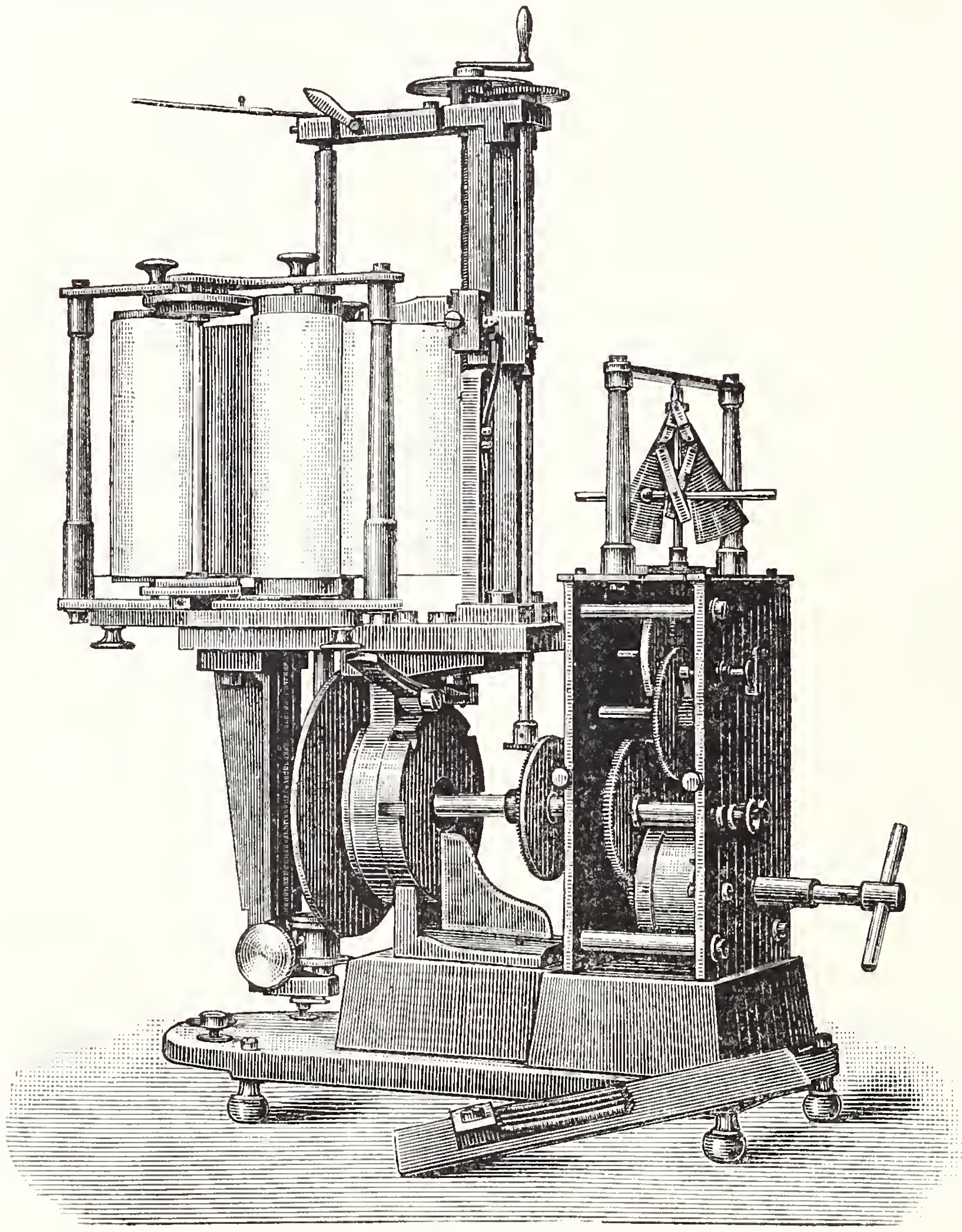


Fig. 1.

As soon as the pawl engages into the desired notch the lever should be slightly pressed against the notch so as to ensure a firm grip. By this means the cylinder may be made to occupy the following positions: towards the left horizontally, obliquely and vertically, towards the right obliquely and horizontally, and while making these changes there is no need to unscrew the frame or to detach the cylinder. In addition, the friction wheel is attached to a long spindle fitted at the top with a pinion movement by which it can be raised and lowered so as to gradually shift the position of the friction wheel from the centre of the horizontal spindle to the edge of the friction disk. According to the position of the friction wheel the cylinder turns towards the right or left. The advantages of this arrangement are best appreciated when the cylinder is used in its horizontal position, since it can always be made to rotate in the proper direction with respect to the scribing levers, whether it be on the right or left side. The connection between the rate of depression of the drum and its speed of rotation has in this instrument undergone the following modifications:—

The old crown wheel on the main spindle has been replaced by a wheel provided with four toothed screws. The screw-spindle, by which the drum is raised and lowered, is fitted with a small wheel which can be moved so as to engage in one of the toothed rims. A scale facilitates this adjustment, and the mechanism is released automatically as heretofore.

The guide-piece for the drum is situated below the latter and a button at the side provides for the movement by hand of the screw-spindle and drum, so as to place the latter at any time in its highest position. After unscrewing a milled head the upper arm can be turned on a hinge so as to attach or remove Hering's loop.

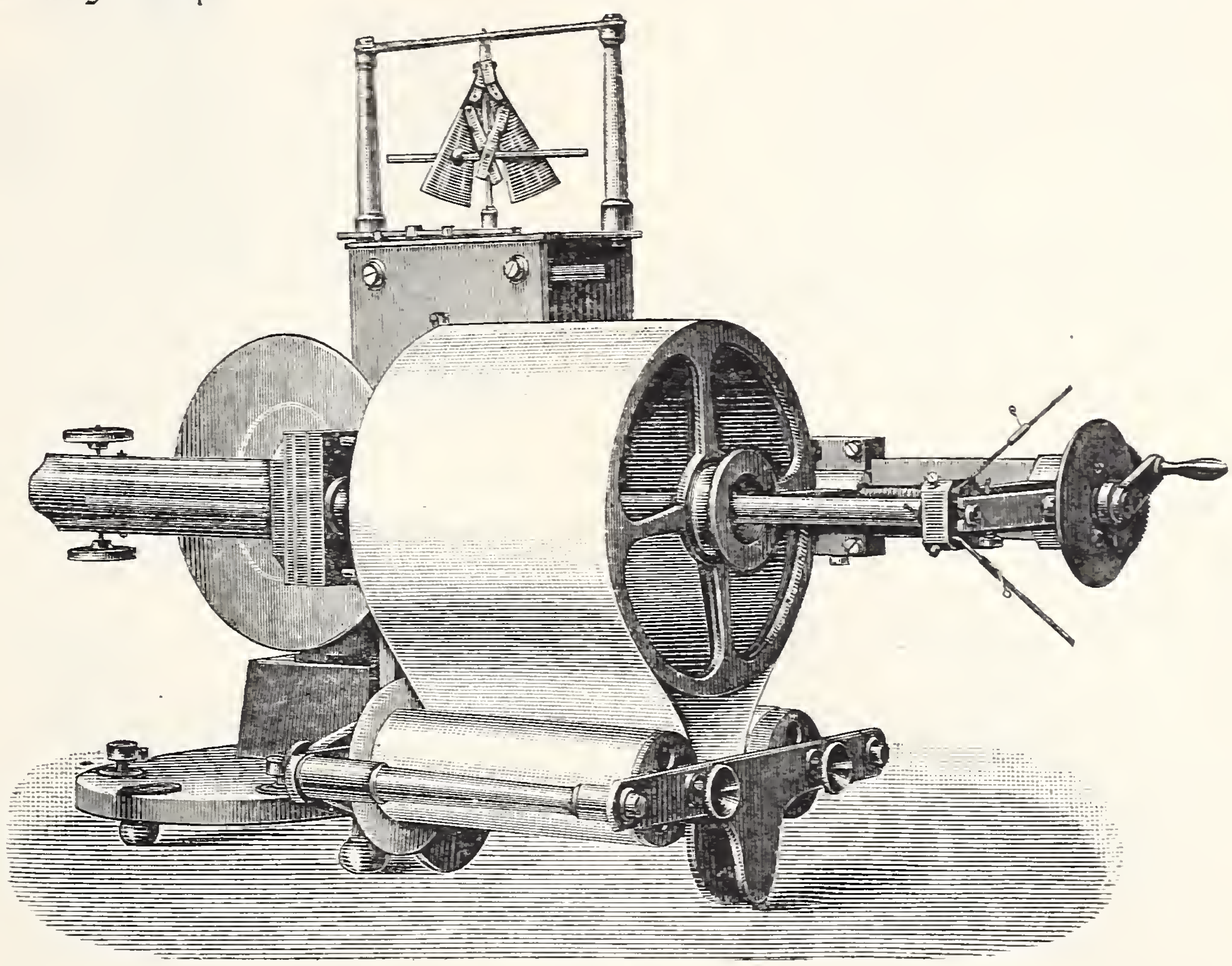


Fig. 2.

The plate of the frame carrying the drum has attached to it a plate fitted with two uprights and a cross-piece supporting two rollers running between points. Fig. 2. Both rollers are constrained to rotate at dissimilar speeds. The left hand roller has a certain supply of ribbon paper rolled upon it, the free end passes round the drum and is clamped to the other roller. As the drum turns the tracing paper is rolled upon the other roller.

The whole apparatus together with these roller fittings can be tilted and the position of the latter reversed when the apparatus is tilted in the opposite direction.

The amount of the downward movement of the drum is indicated by a millimetre scale. The changes in the rotating speed of the drum are effected, as heretofore, by altering the position of the friction wheel or by means of the change wheel nearest the crown wheel in the driving clock, also by loosening the coupling on the main spindle.

By these means the cylinder can be made to rotate at speeds varying from 0.1 to 250 mm per second.

5. Psychiatric Clinic of Giessen.

1. Prof. Sommer's Apparatus for the Three-dimensional Analysis of Expressional Movements of the Hand, made by Schmidt, mechanician, Giessen. Fig. 1.

2. Prof. Sommer's Apparatus for the Three-dimensional Analysis of Movements of the Legs. Fig. 2.

3. **Prof. Sommer's Apparatus for the Examination of the Pupils,** with means for measuring the stimulus and its effect. Accessory:—A rheostat for modifying the optic stimulus. Fig. 3.

(A description of these instruments is contained in the Lehrbuch der psychopathologischen Untersuchungsmethoden by Prof. Sommer, of Giessen, pp. 82 to 139.)

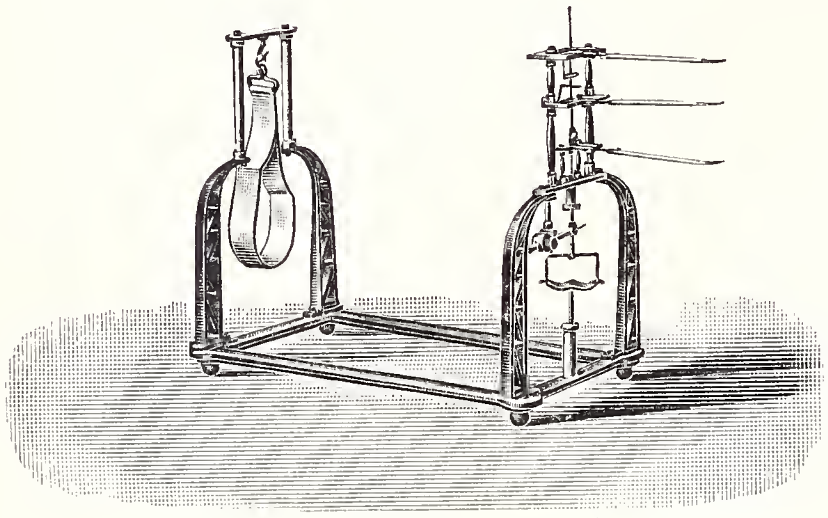


Fig. 1.

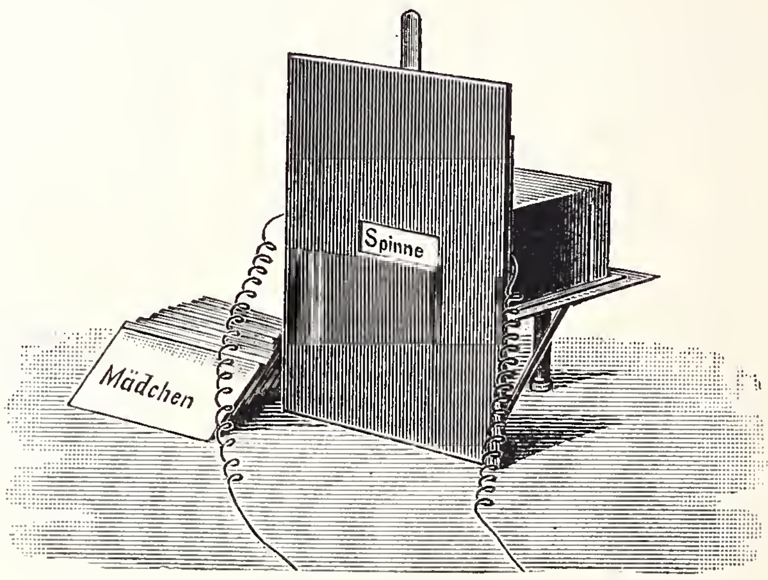


Fig. 4.

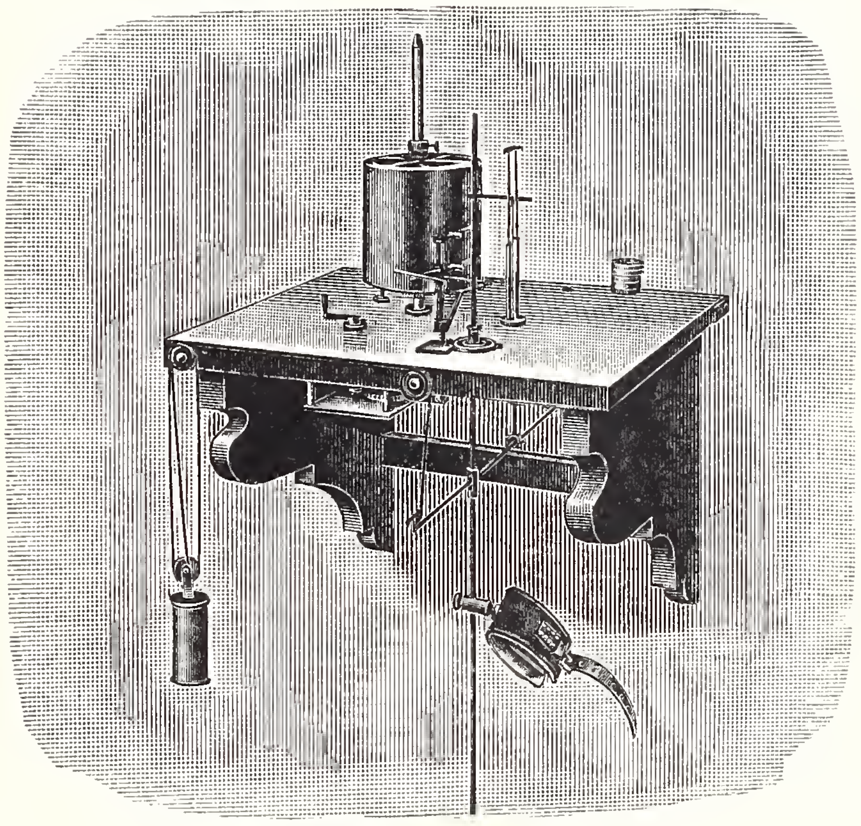


Fig. 2.

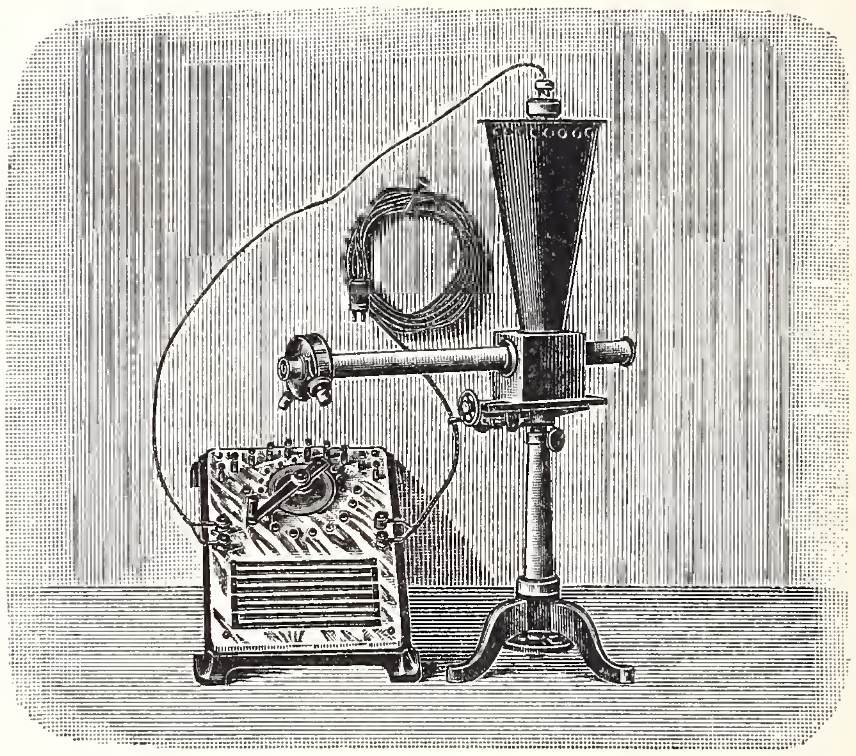


Fig. 3.

4. **Dr. Alber's Apparatus for Resolving Optical Stimuli.** Fig. 4. See Archiv für Psychiatrie und Nervenkrankheiten, Berlin 1898. Vol. 30. No. 2.

Instruments Nos. 2 and 4 have been made by G. Hempel, mechanician to the Clinic.

6. Siemens & Halske Limited, Berlin.

(See also Sections IV, Va and VI.)

1. **Induction Coil giving a spark of 20 cm,** mounted on mahogany case with condenser, commutator, Deprez contact-breaker with interchangeable platinum double contact and double primary winding, adapted for working both with the Deprez or mercury interrupter and a Wehnelt contact-breaker (Fig. 1).

2. **Induction Coil giving a spark of 30 cm,** similar in construction to No. 1.

3. **Induction Coil giving a spark of 50 cm,** similar in construction to No. 1, but without Deprez interrupter.

4. **Induction Coil giving a spark of 30 cm,** mounted on base without condenser, with primary winding, adapted for the Wehnelt interrupter only.

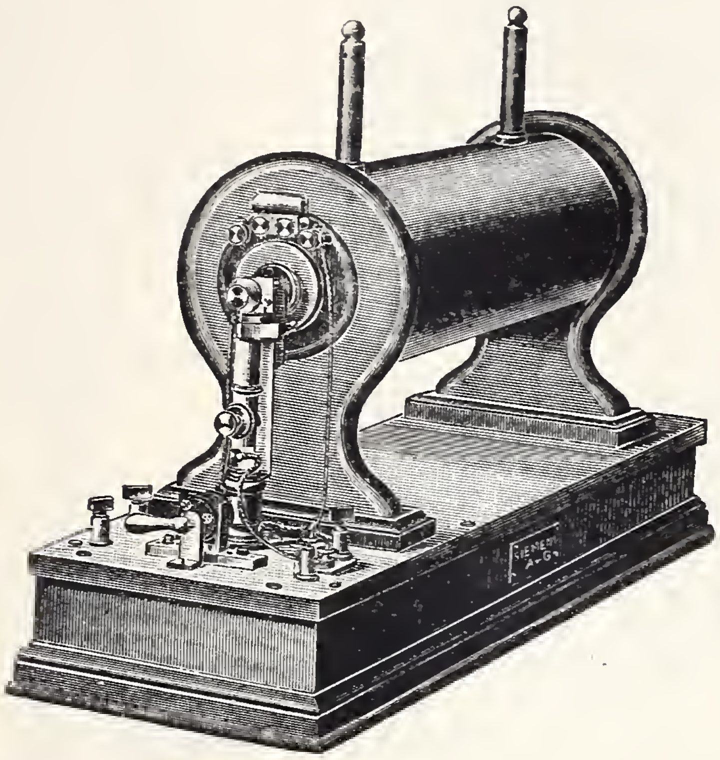


Fig. 1.

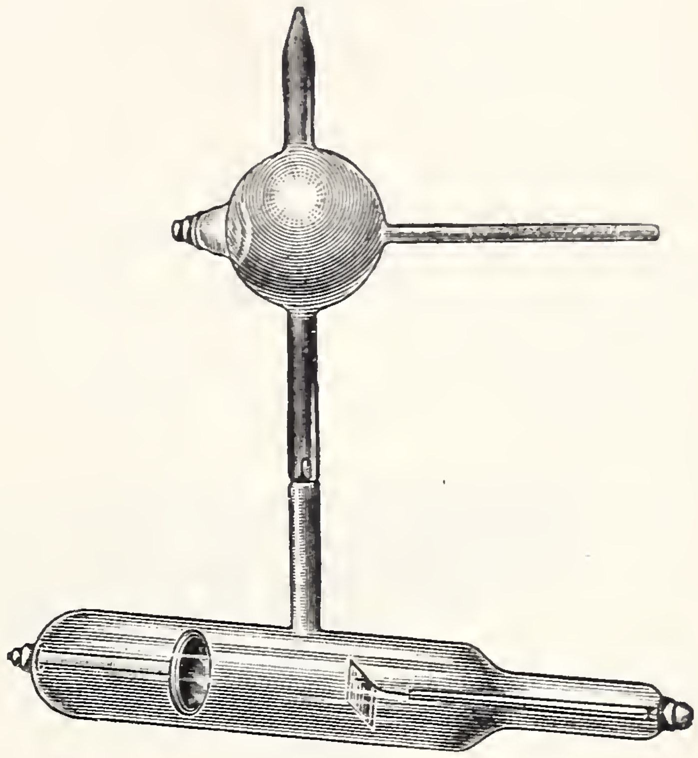


Fig. 4.

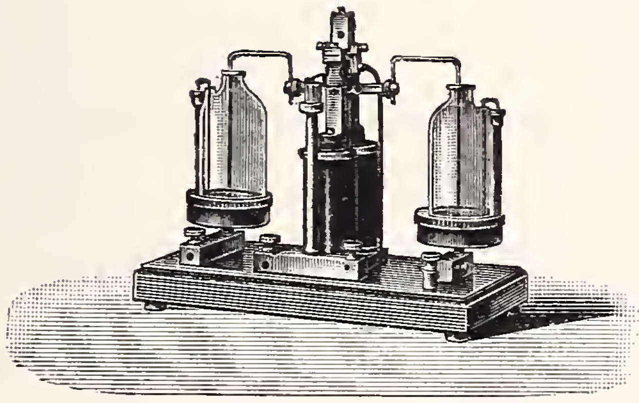


Fig. 2.

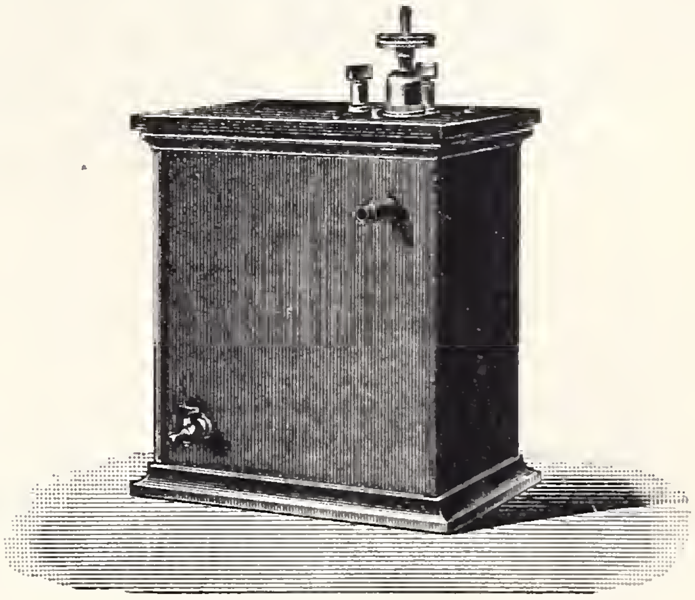


Fig. 3.

5. **Mercury Vibrator** on mahogany board with double armed balance beam, to work with a primary current of 12 to 30 volts and adapted for continued working. The apparatus is appropriately put in the circuit of the primary coil, the frequency of interruptions is regulated by means of two set-screws, which vary the duration of the contact in the primary circuit (Fig. 2).

6. **Wehnelt's Electrolytic Contact-breaker** for continuous and alternating currents, with cooler and easily adjustable anode for regulating the strength of the current and the frequency of the interruption within very wide limits varying from 30 to 2,000 interruptions per second. Adapted for direct working at 50 to 220 volts (Fig. 3).

7. **Röntgen Tube with Adjustable Vacuum** for ordinary interrupters, of the Deprez and mercury vibrator type. By means of the phosphorus placed in an accessory tube the Röntgen tube can be adjusted to any desired length of spark up to 30 cm (Fig. 4).

8. **Röntgen Tube for Wehnelt's Interrupter,** adapted for a 30 cm spark, with arrangement for cooling the anticathode.

7. Emil Sydow, Berlin N.W. 6, 17 Albrechtstr.

Mechanician and Optician to the University Ophthalmic Hospital.

Several awards, gold and silver medal, diplomas and certificates.

Speciality: Ophthalmic Instruments, Ophthalmoscopes, Laryngoscopes, Reflex Mirrors.

1. **Set of Standard Test Lenses** of the latest, most elegant and most perfect form. All the glasses are mounted in silvered or gilt frames. The cylindrical lenses are partly greyed as an aid in finding their axes. The equipment is complete and suffices for all purposes. Further particulars will be found in the firm's catalogue under No. 177.

2. **A Similar Set,** in case made throughout of solid walnut, and fitted with wooden divisions. Attention is drawn to the improved diopter scales which are made of celluloid.

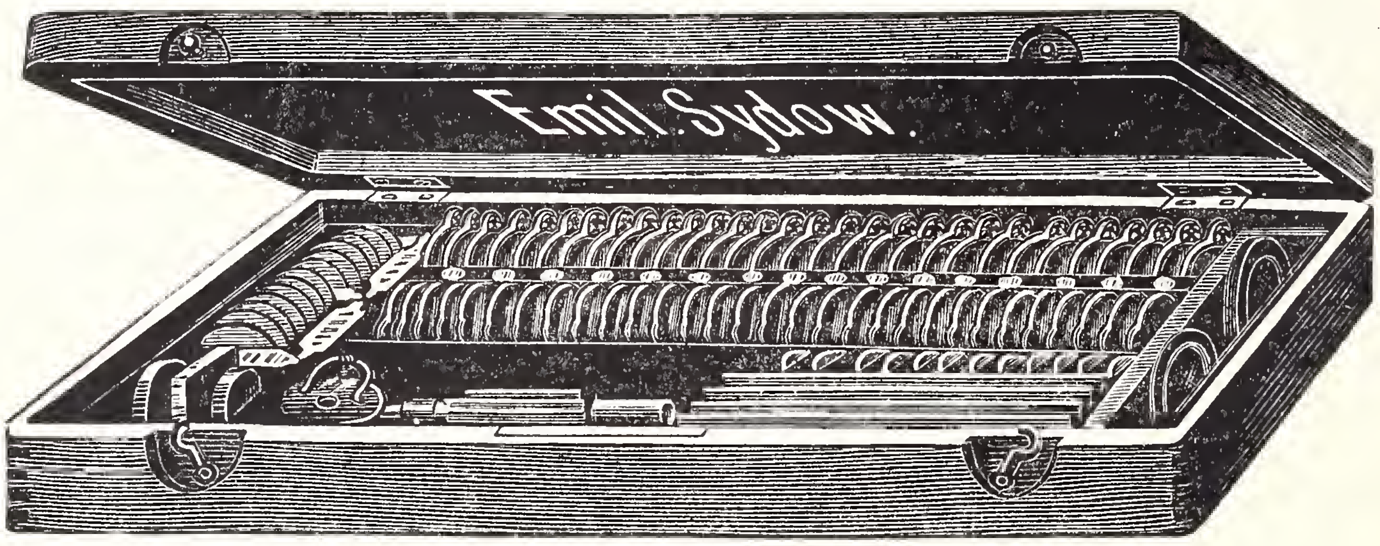


Fig. 1.

3. **Military Spectacle Test Case No. II,** as supplied to the German Army. The case is made of oak. Fig. 1.

4. **Helmholtz's Ophthalmometer.**

5. **Förster's Perimeter, Pedrazzoli's Perimeter, Schweigger's Hand Perimeter.**

6. **A Set of the Latest Refraction Ophthalmoscopes,** named and arranged in elegant cases.

7. **Various Refraction Ophthalmoscopes.**
   a) **Automatic Refraction Ophthalmoscopes** after Knauer and Roth. Figs. 2 and 3.
   b) **Refraction Ophthalmoscopes** after Schweigger, Knapp, Hirschberg, Burchardt, Haab, Landolt, de Wecker, Morton, Loring, Noyes, Lyder-Borthen and others.

8. **Liebreich's Large Demonstration Ophthalmic Mirror. Peppmüller's Demonstration Ophthalmic Mirror.**

9. **Skiascopes.** Roth's automatic skiascope, amply tried and used in many hundreds. Schweigger's skiascope; Hori's skiascope; Neustätter's skiascope; Antonelli's skiascope.

10. **Universal Trial Spectacles and Simple Test Glasses.** Burchardt's universal test spectacles made of aluminium, a greatly approved model. Also Schweigger's, Roth's, Gutmann's, Nacket's, Unger's trial spectacles, and others. Fig. 4.

11. **Corneal Lenses.** Zehender-Westien's binocular corneal lens for direct corneal observation, the best binocular lens extant; a similar binocular lens by Eilhardt Schulze. Hartnack's corneal lens.

Fig. 2.

Fig. 3.

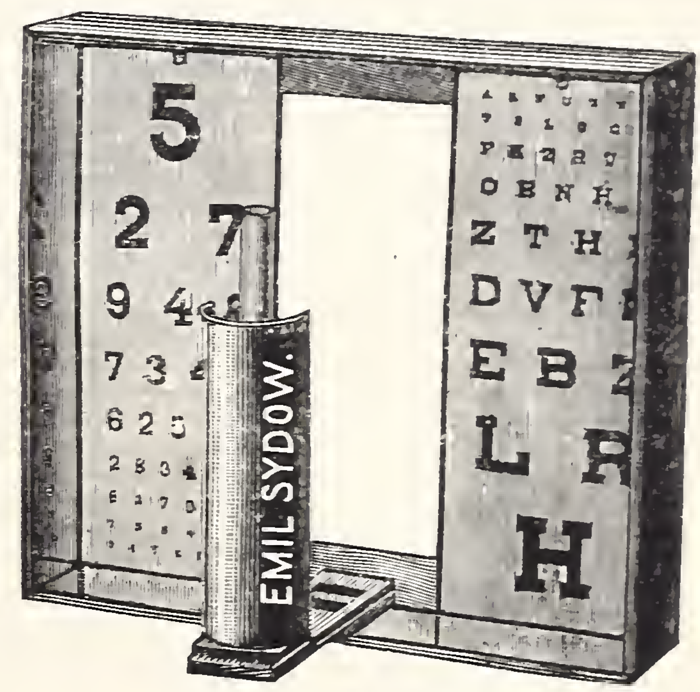


Fig. 5.

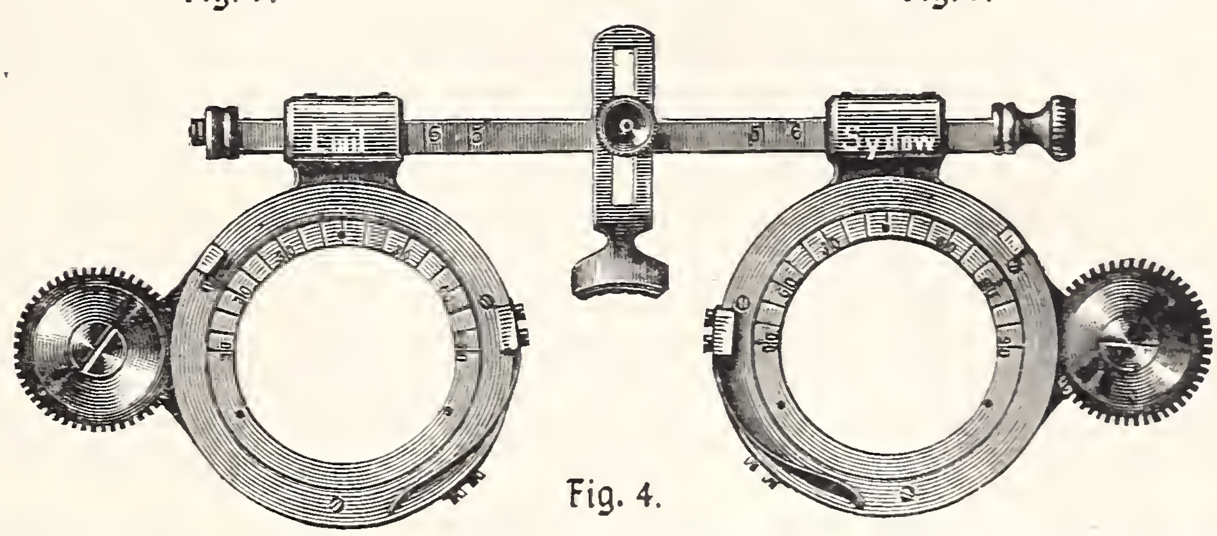


Fig. 4.

12. **Schweigger's Electrical Illuminating Lamp for the Cornea;** the same with lateral Hartnack lens, &c., various patterns.

13. **Roth's Sight Testing Illuminating Apparatus.** Fig. 5.

Laryngoscopes, Reflectors, Larynx Mirrors.

8. E. Zimmermann, Leipzig, 21 Emilienstr.

1. **Wundt's Chronograph,** for measuring extremely small intervals of time, capable of reading 0.001 second, primarily designed for the study of psycho-physical processes. A drum 320 mm long and 620 mm in diameter is driven by a powerful clockwork and may, by adjustable weights and a fan governor, be made to run at a maximum speed of ten revolutions per second. A micrometer spindle turns synchronically with the drum and transports an electro-magnetic tracing apparatus consisting of

a small tuning fork, calibrated to make 500 double vibrations per second and fitted with a writing style, and three pairs of electromagnets with scribing points.

2. **Ludwig's Drum Kymograph,** being a registering apparatus with drum adapted for use both in the horizontal and vertical position. The drum can be raised by a slide actuated by a micrometer-screw and is lowered automatically by the clockwork. The latter provides for a range of the curve interval from 2 to 35 mm, and the speed of rotation may be varied continuously from 2 seconds to 1½ hours.

3. **Universal Stand for Graphic Experiments in Physiology.** This stand is adapted for supporting and adjusting the distance of the writing apparatus from the smoked drum and possesses the advantage that all scribing instruments and time markers can be moved up and down in the same plane and adjusted both roughly and by a micrometer-screw with respect to the drum, whilst the latter may work either in the horizontal or vertical position.

4. **Piston Recorder** with balanced writing lever, the fulcrum of which can readily be shifted within wide limits.

5. **Marey's Pneumograph** for registering movements during breathing.

6. **Marey's Tambour** with detachable holder for the scribing levers and movable fulcrum, for registering oscillations in blood pressure, &c.

7. **Von Frey's Tonograph,** for similar purposes. In this instrument the rubber membrane is replaced by a flat corrugated sheet metal box, which possesses the advantage of greater constancy, durability and air-tightness.

8. **Recording Magnet,** for registering intervals along the respiratory curves.

9. **Electrically Maintained Spring,** for the same purpose.

10. **Bernstein's Oscillating Contact Breaker,** for actuating both time markers. This instrument possesses the advantage that, the spring being graduated in terms of vibrations per second and micrometrically adjustable by means of a scale, interruptions may be obtained varying from 3 to 250 per second.

11. **Universal Contact Apparatus (Reaction Time Chronograph).** This apparatus suffices to establish contacts giving any interval and duration of time, e. g.:

1. Absolutely instantaneous contacts.
2. Triangular friction contacts.
3. Rotating contacts for permanently closing circuits.

The latter, by suitable combinations, are adapted for producing durations of contact varying from immeasurable shortness to any length of time.

12. **Von Frey's Sphygmograph,** for tracing pulse curves, so constructed that the scribing lever traces the pulse movements either directly from the pressure plate upon a specially constructed clockwork fitted with interchangeable drums and registering intervals of $^1/_5$ second, or by a pneumatic capsule, or by direct transmission upon any of the usual kymographs.

13. **Minot's Automatic Microtomes.**

These microtomes are made in various forms and sizes and have been described as the best, most complete and most convenient section-cutters. They possess the following advantageous features:—All parts are so solid as to be almost indestructible; the v-block moves freely and uniformly and yet with great precision; the thickness of the sections is variable from ½ to 40, and, in one instrument, even 100 micro-millimetres; the micrometer-screw is fed automatically, the form of the instrument is adapted for very large sections, e. g. entire brain-sections; the position of the object is adjusted while wholly above the knife, which is stationary and fixed at both ends; the object can be adjusted in any position with the greatest ease; the sections are absolutely flat and are obtained quickly and without trouble.

Model I is adapted for cutting 40×40 and 40×50 mm having a thickness of 35 mm and furnishes automatically the following range of thicknesses:

$^1/_{300}$, $^1/_{150}$, $^1/_{100}$, $^1/_{75}$, $^1/_{60}$ and $^1/_{50}$ mm, or, as expressed in micro-millimetres,
3, 6, 10, 13, 16 and 20 microns.

If desired, this as well as all the other models, can be constructed so as to cut any other series of thicknesses.

Model II is of the same size as Model I, but, in addition to the cutting series of the latter, furnishes sections having thicknesses of 1, 2, 3, 4, 5 and 6 microns.

Model III is adapted for objects 55×60×45 mm thick, and is used like Models I and II, but has an additional frame for cutting celloidine preparations with the knife clamped in an oblique position. This model furnishes sections of 6, 13, 20, 26, 33 and 40 microns and $^1/_2$, 1, $1^1/_2$ ... to 6 microns.

Model IV, similar in size to Model III and fitted with the oblique knife frame; but without the micrometer adjustment, which is not required in many cases. It furnishes sections of 5, 10, 15, 20, 25 and 50 microns.

14. Microtome for Brain-sections. New Model.

Model V, as suggested by Dr. G. C. van Walsem. This instrument possesses all the features of the preceding models and, in addition, is adapted for obtaining sections of the cerebral hemispheres, the ganglia of the caudex cerebri on both sides and the cerebellum, and, besides the smallest sections, objects of 115×195 mm can be cut. It furnishes sections of $^1/_2$, 1, $1^1/_2$ ... to 6 microns and 9 progressive thicknesses from 6 to 100 microns. It is also well adapted for cutting celloidine preparations.

Model VI is adapted for large sections of 115×195 mm only. Any of the fittings necessary for cutting fine sections are absent in this instrument, so as to reduce the instrument to its simplest form. It furnishes accordingly only the coarser series of Model V, viz. 6, 13, 20, 26, 33, 40, 60, 80 and 100 microns.

15. Two New Sliding Microtomes with automatic feed, transverse or oblique stationary knife clamped at both ends.

16. Burghart's Automatic Microtome, with a transverse or oblique stationary and a rotating knife, the latter being intended for fresh objects.

An illustrated price-list and separate descriptions may be had on application.

9. Ad. Zwickert, Kiel, 25 Dänischestr.

Optician. Mechanician to the Royal Physiological Institute of Kiel.

Gold Medal and Diploma: Kiel 1896. Gold Medal: Brussels 1897.

(See also Section IX.)

1. Dr. Apstein's Medium Sized Plankton Net. This net is adapted for the quantitative catching of plankton, the organisms floating arbitrarily in water. It is drawn vertically and the amount of filtered water can be estimated from the opening of the net and the depth of the draw.

2. Dr. Apstein's Small Plankton Net. This net is used like No. 1. When travelling it can conveniently be carried in a knapsack.

3. Plankton Net for Fish-ponds. Walter's modification of No. 2. This net is used like Nos. 1 and 2 and serves to determine the amount of nutriment in fish-ponds.

4. Dr. Apstein's Surface Net. This net is intended for qualitative fishing. The material collects at the detachable gauze closing the bottom of the bucket.

5. Prof. Hensen's Counting Microscope. This microscope serves for counting the quantitatively dredged organisms. Attention is drawn to the ruled glass plate and the movement of the stage in two directions.

6. Zwickert's Counting Stage. Similar to No. 5, but simpler. Adaptable to any microscope.

7. Prof. Hensen's Piston Pipettes for extracting from a vessel containing the well stirred catch a certain volume (0.1, 0.2, 0.5, 1.0, 2.0, 5.0 ccm) so as to separate a definite portion for counting.

8. Prof. Hensen's Large Filtrator, for concentrating the yields. The yields of the plankton net buckets are placed into the filtrator and the superfluous water can be removed.

VIII. Appliances for Chemical and Chemico-physical Research, Laboratory and Educational Apparatus.

1. Paul Gebhardt, Berlin C., 6 Neue Schönhauserstr.

Mechanician and Optician. (Established 1870.)

Factory and Warehouse for Scientific, Electrical, Optical and Chemical Instruments and Appliances for Class Demonstration (The Berlin Educational Stores).

Mechanics.

Stand with Pulley Block, of metal.

Air-pump with two Glass Barrels (26×6 cm), Babinet cock, with disk 27 cm and vacuum-gauge (Fig. 1).

Dasymeter.

Magdeburg Hemispheres (12 cm), of brass.

Barometer Test.

Bourdon's Tube.

Hydraulic Press, of brass.

Suction-pump.

Recipient for Air-pump (30×25 cm).

Rotating Machine of iron, to work horizontally and vertically.

Watt's Regulator.

Bohnenberg's Rotator.

Eriometer after Gravert, with dynamometer; after Thaer-Kleinert; after Menzel; after Dr. S. Hartmann.

Acoustics.

Two Tuning-forks on sounding board.

Simple Syrene.

Cagniard-Latour's Syrene with counting mechanism (Fig. 2).

Savart's Wheel-syrene.

Reed-pipe with sounding funnel and glass window.

Pipe with tonic scale.

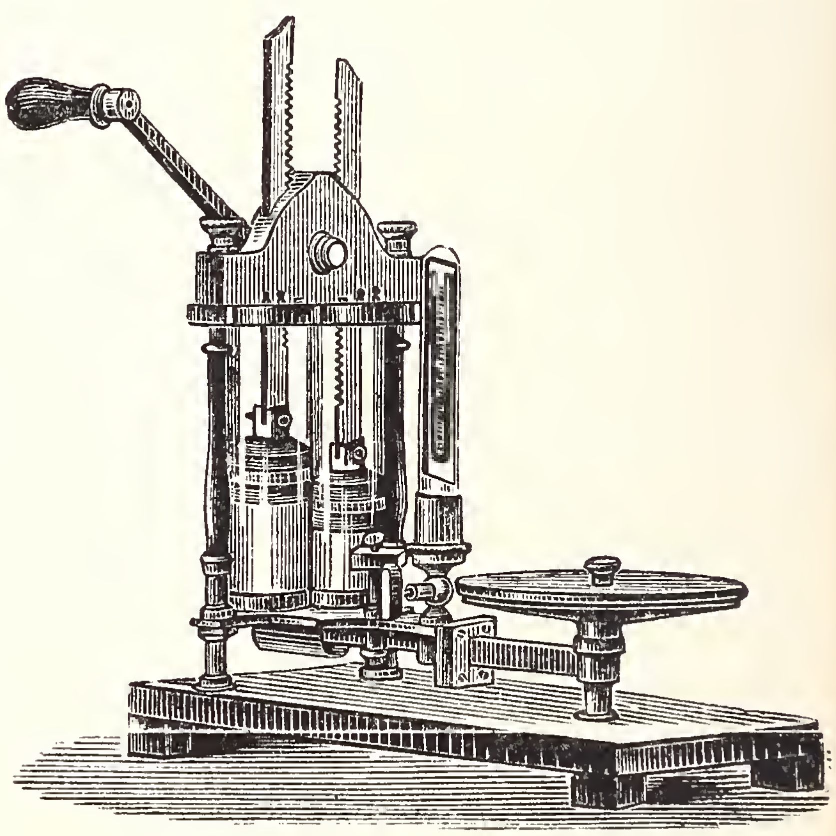


Fig. 1.

Optics.

College Spectroscope with covered prism, fixed slit collimator, scale-tube and telescope, adjustable.

Polariscope with Nicol prism, fitted with pointer, two divided circles, graduated arc, lenses and crystal-holder.

Large Convex and Concave Lens on adjustable stand and movable.

Prism on stand.

Model of Microscope, open, with drawing showing path of rays.

Mechanical Goniometer.

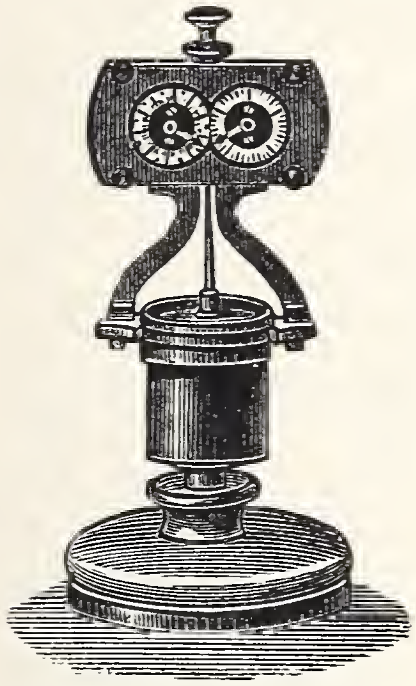
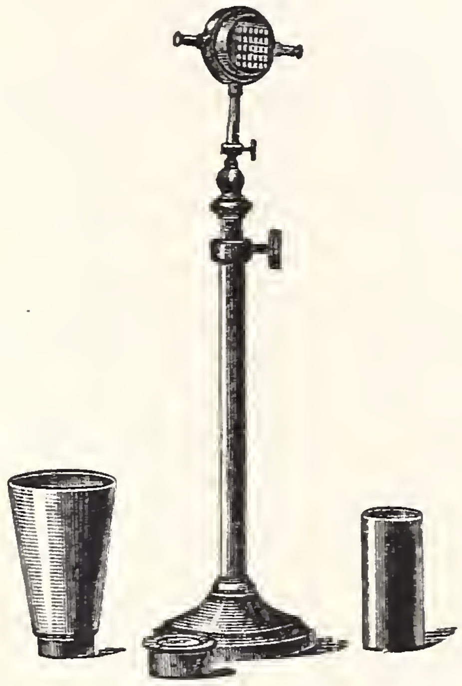


Fig. 2.



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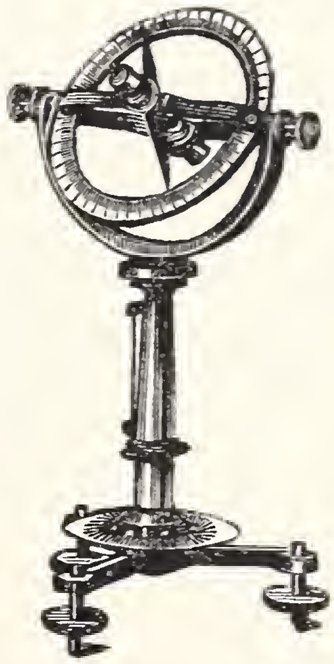


Fig. 4.

Heat.

Sectional Working Model of vertical steam-engine, cylinder with slide-valve gear, excentric, regulator, throttle valve.

Leslie's Copper Cube.

Döbereiner's Lamp in glass cylinder.

Lever-pyrometer together with four rods of different metals.

Tyndall's Contraction Apparatus.

Nobili's Thermo-electric Pile, consisting of 30 elements on movable and adjustable brass-stand (Fig. 3).

Magnetism.

Load-stone, natural.

Load-stone, mounted.

Horse-shoe Magnet, triple laminated.

Compound Magnet, in case.

Magnet Needle (18 cm long) with agate centre, on stand, in case.

Declination and Dipping Needle with agate centre, graduated circle revolving in fork, adjustable by micrometer-screw (Fig. 4).

Electricity.

Coulomb's Torsion Balance for magnetic and electrical experiments in graduated glass vessel.

Rotating Glass Sphere.

Tangent Galvanometer, copper ring of 32 cm diameter on polished mahogany stand.

Galvanometer with astatic needle, under glass shade (Fig. 5).

Demonstration Apparatus, current flowing round a magnet, with commutator (Fig. 6).

Rotating Magnet Apparatus, in three combinations.

Ampère's Apparatus after Weinhold, with aluminium electrodes, two stands, two coils and two boxwood cups.

Carbon Regulator with parabolic reflector.

Vertical Demonstrating Galvanoscope with two different windings and adjustable coils (Fig. 7).

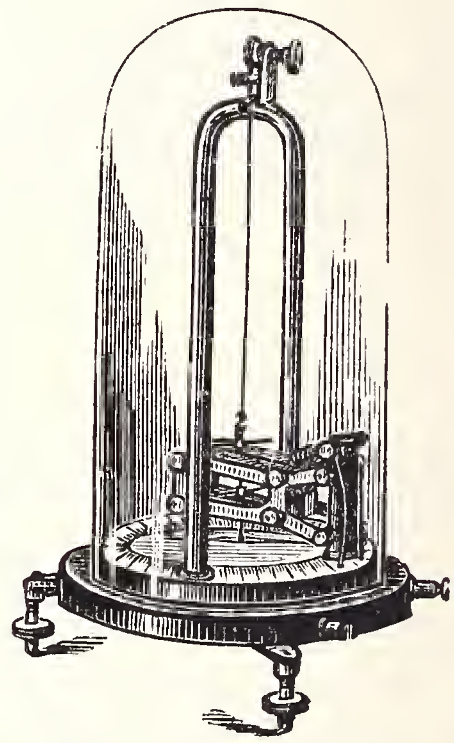
Electromotor for Geissler tubes.

Geissler tubes.

Electrical Egg, bisected.

Rhumkorff Induction Coil, 8 mm spark, with commutator.

Telephone Model (Fig. 8).



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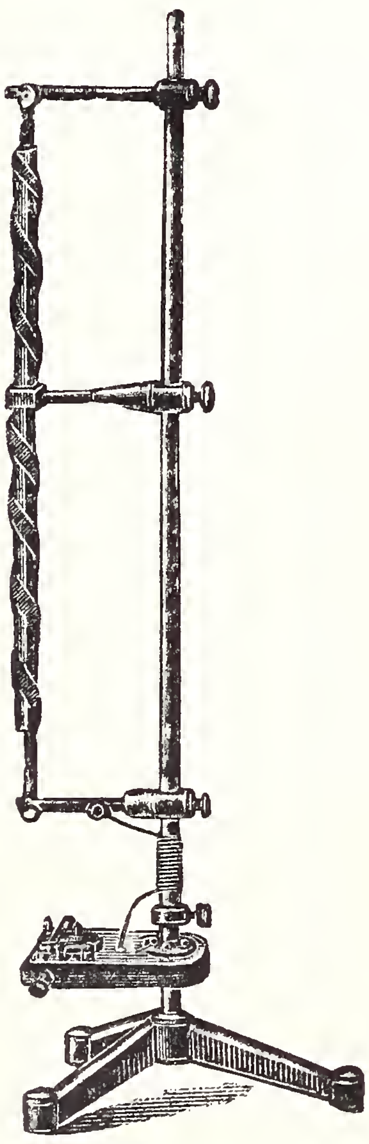


Fig. 6.

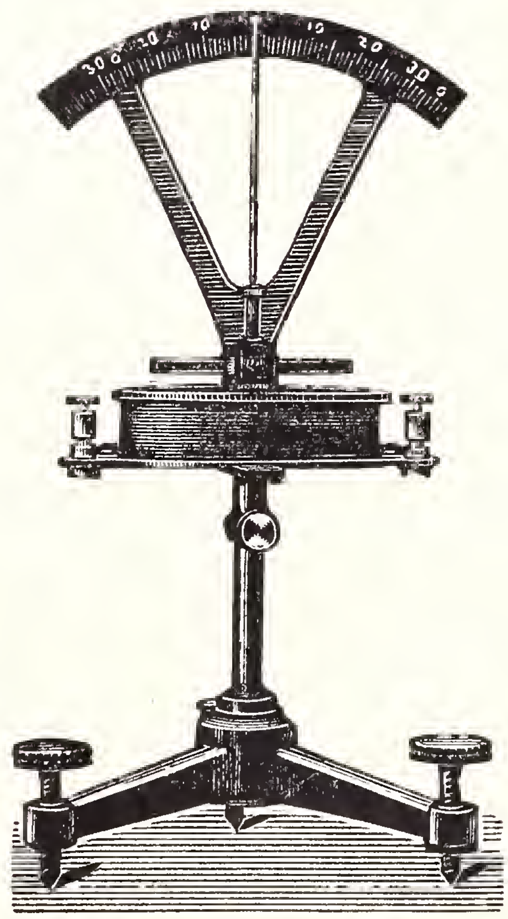


Fig. 7.

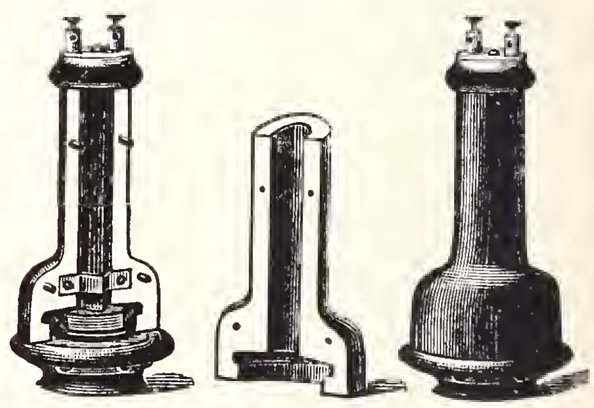


Fig. 8.

Illustrated catalogues may be had gratis on application.

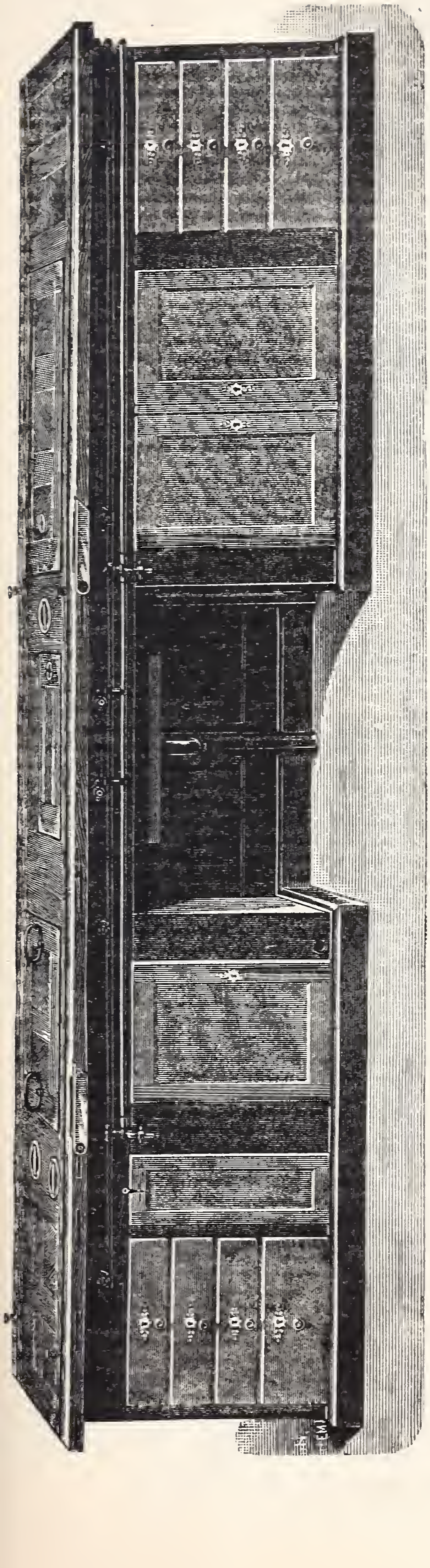


Fig. 1.

2. Max Kohl, Chemnitz (Saxony).

(See also Section VII.)

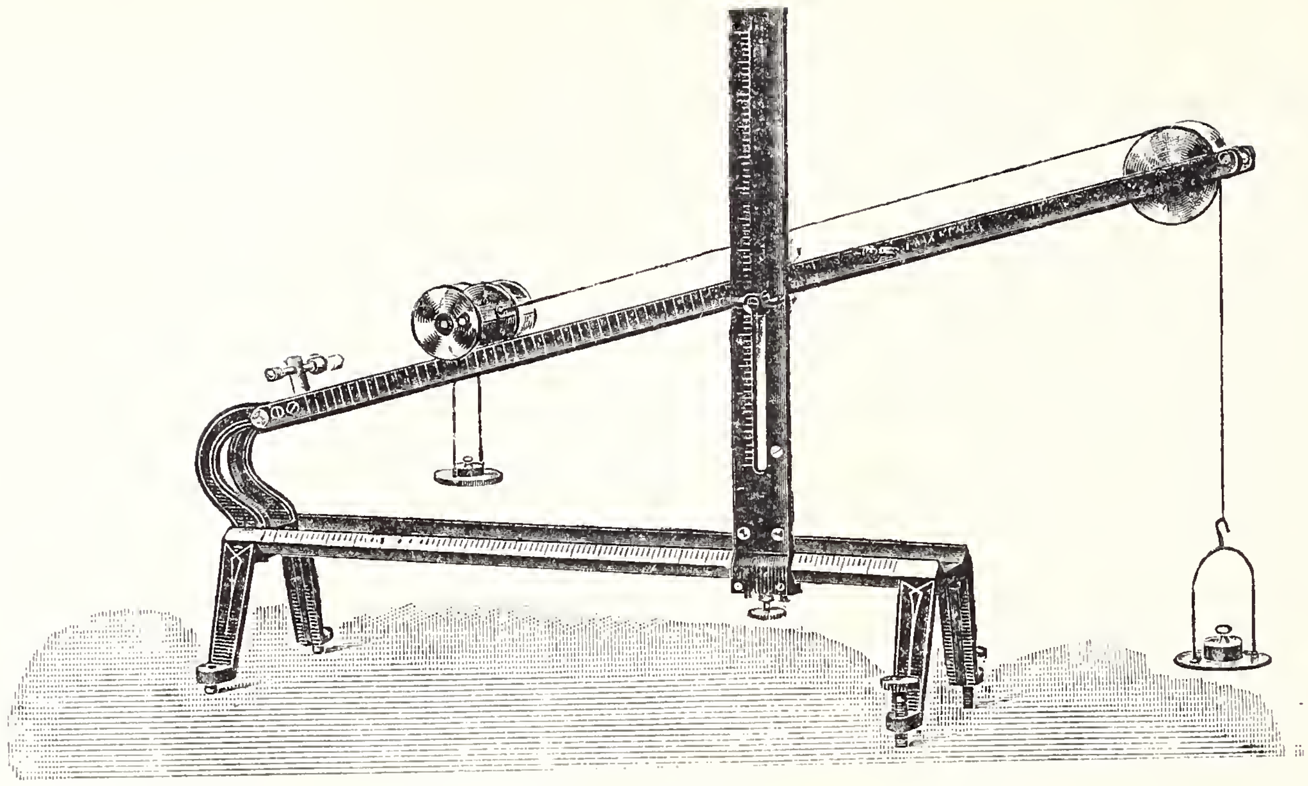
1. **Weinhold's Experimenting Table** for teaching in physics. Fig. 1. This table is 4 m long, 0.9 m high and 0.8 m wide. The table is of oak 40 mm thick and made up of framed pannels. The body of the table consists of deal frames and pannels; it is fitted with eight drawers and two cupboards, a long narrow drawer for glass-tubes and a bracket for placing burners aside. The table is fitted with gas and water pipes, two sets of piping for a water vacuum pump and a water blower, also two lead waste pipes, a draught pipe for gases and obnoxious fumes, a warming chamber for electric apparatus, recesses for experiments involving the use of mercury, a pneumatic zinc trough with outlet valve, electric wire connections, two India rubber flaps and tube holes. All pipes are fitted with excellent taps and are laid ready for connection through the floor. The gas piping includes a specially wide cock for filling gasometers, the other gas-cocks are fitted with curved nipples to prevent kinking. The covers above the water outlets and the draught pipe are of iron and rest on iron rings so as to obviate the inconveniences arising from warping. The cover of the pneumatic trough is for the same reason made to consist of a slab of slate. This slab, as well as the cover of the mercury-well and the warming chamber, are made to lift out by means of detachable handles. Opposite the draught canal the table is fitted with a slab of slate 54 qcm so as to protect the table from injury during the performance of chemical experiments. The understructure is varnished.

2. **Bertram's Inclined Plane,** Fig. 2, made entirely of metal and adjustable so as to alter the direction of the pulling force.

3. **Model of the Hydraulic Press,** Fig. 3, consisting of a glass barrel fitted with visible valves. The communication pipe is exposed to view, and the large cylinder is fitted with a safety valve.

4. **Weinhold's Form of Pascal's Apparatus** for experiments on the hydrostatic pressure at the bottom of differently shaped vessels. Fig. 4. The beam has on one side a top pan so as to facilitate the interchange of the vessels.

5. **Hydrostatic Balance.** Fig. 5. This balance is fitted with beam and pan arresters. The case can readily be lifted off after turning two fasteners and is fitted with back and front sliders. The balance is sensitive to 5 mg and carries 1,000 g on each pan. It is adapted both for specific gravity and other accurate weighing. The equipment of the balance includes a short pan and an adjustable support for hydrostatic experiments.



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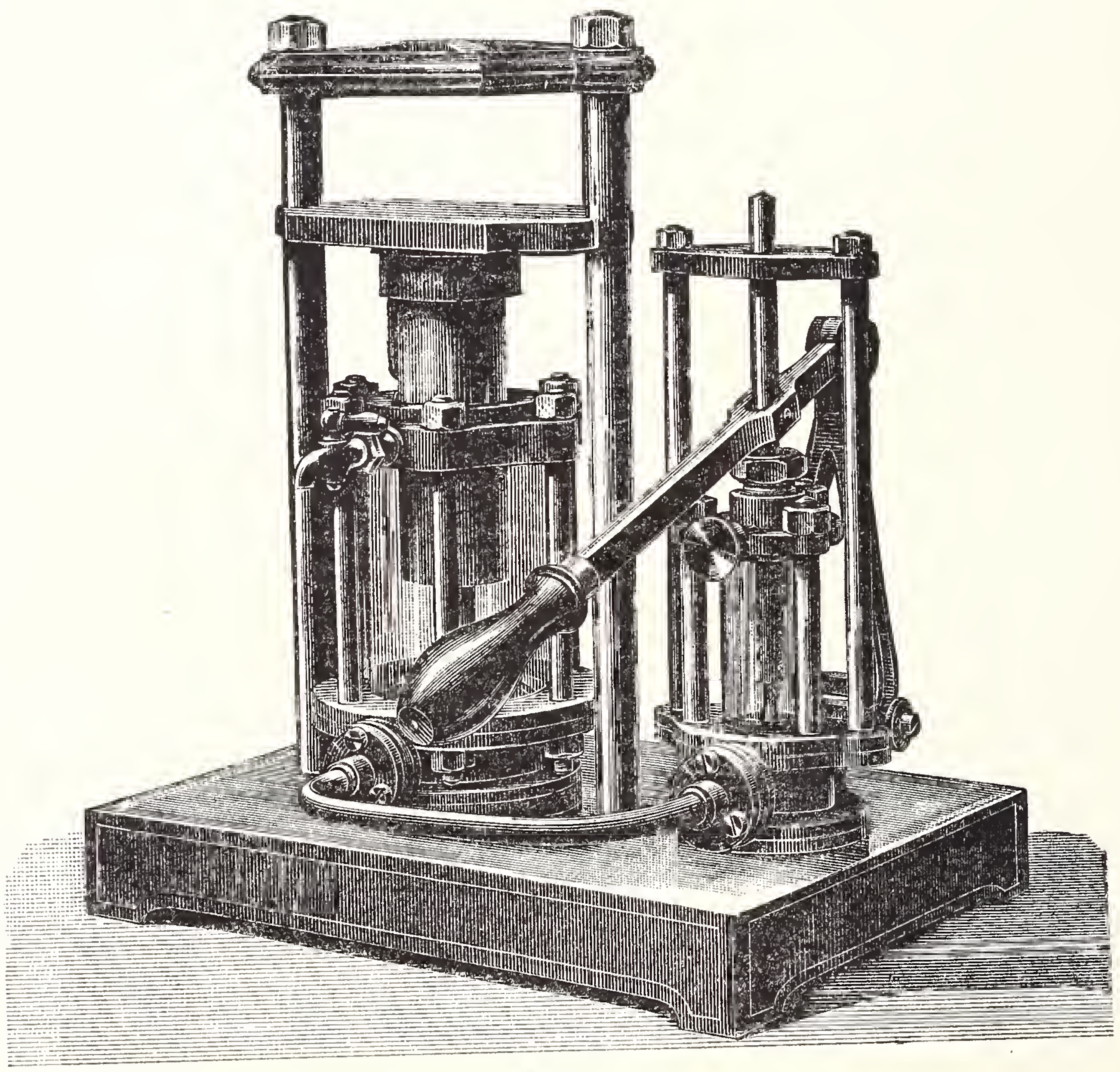


Fig. 3.

6. **Syphon Barometer**, Fig. 6, mounted on a heavy ebonized board. The tube is stout, thoroughly boiled out and fitted with a fused-in point and ebonite stopper for the safe removal of the instrument. The scale is made of boxwood, it is movable and fitted with two diopters.

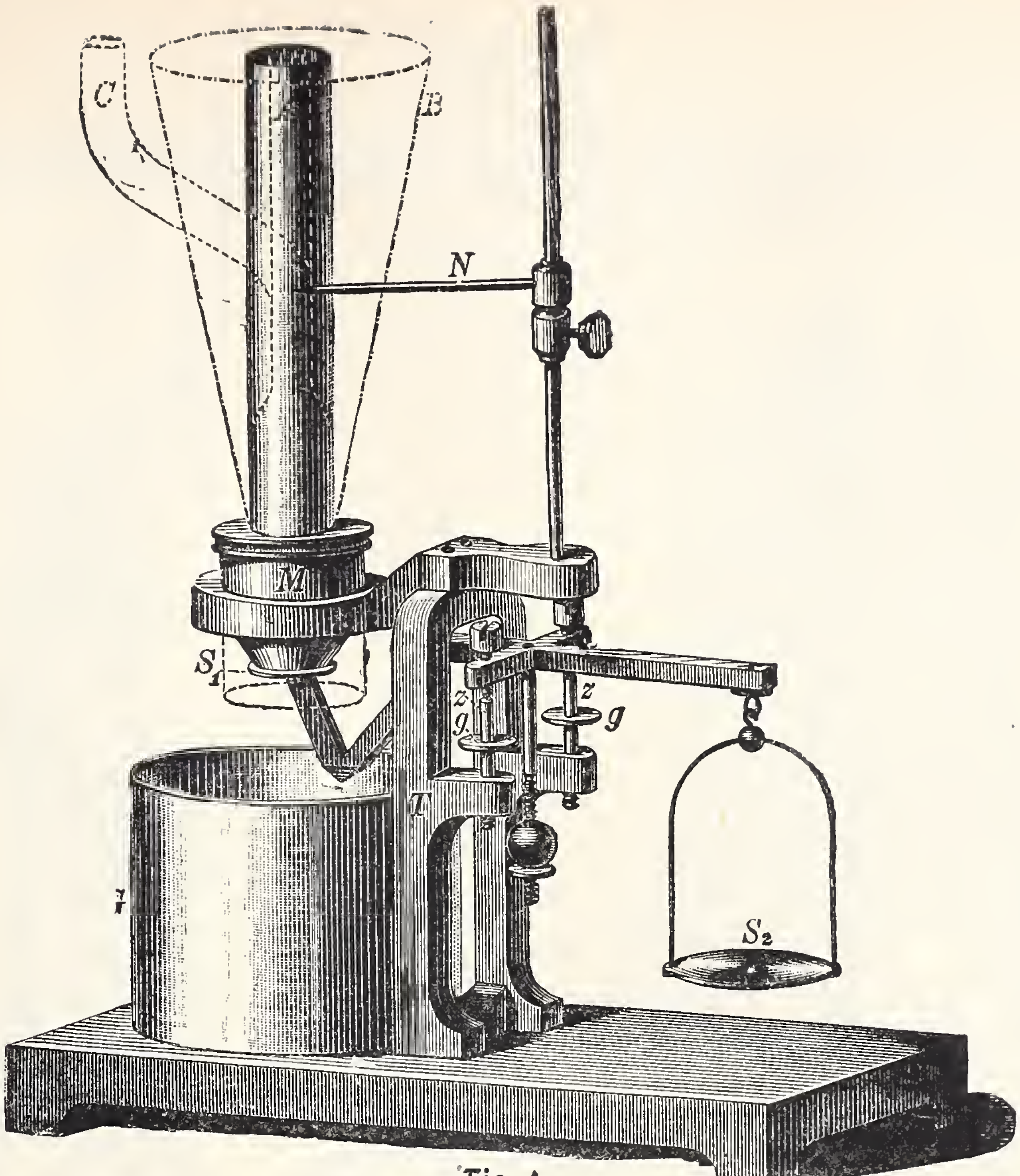


Fig. 4.

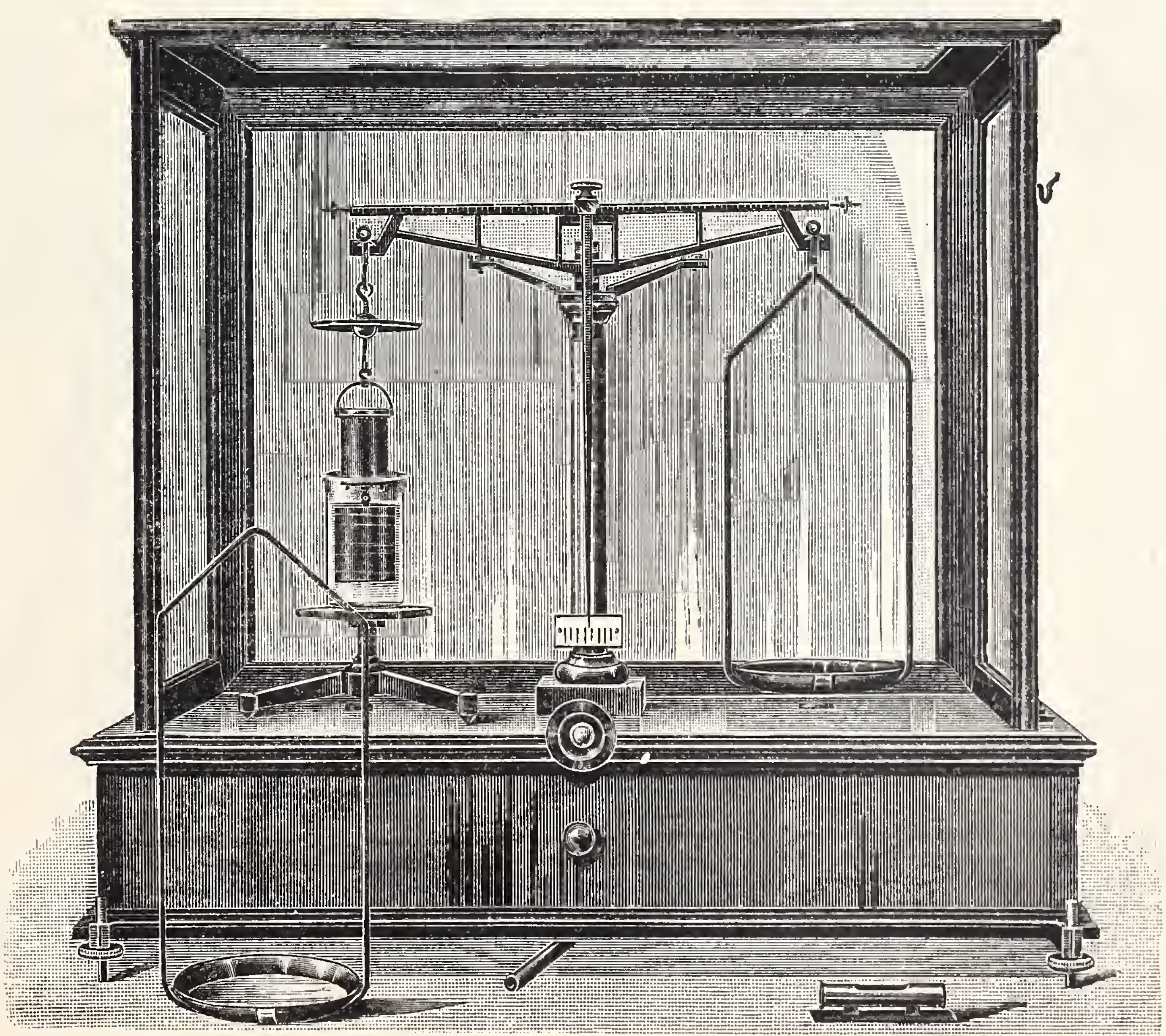


Fig. 5.

7. Fortin's Stationary Barometer. Fig. 7. The tube is 15 mm wide and contained in a metal casing. A vernier moved by a screw admits of $^1/_{20}$ mm being read off. The lower level of the mercury is adjustable by an elevating screw.

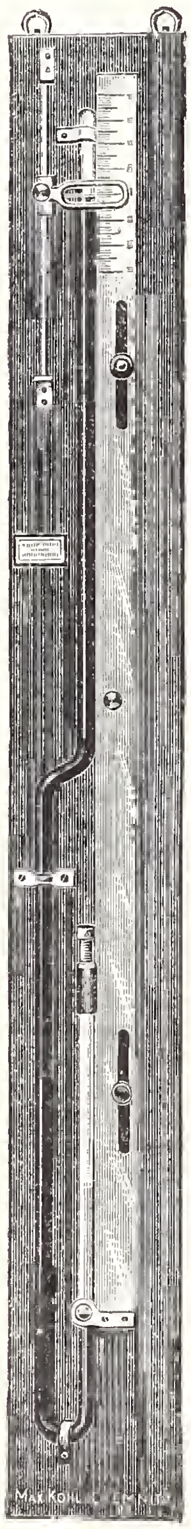


Fig. 6.

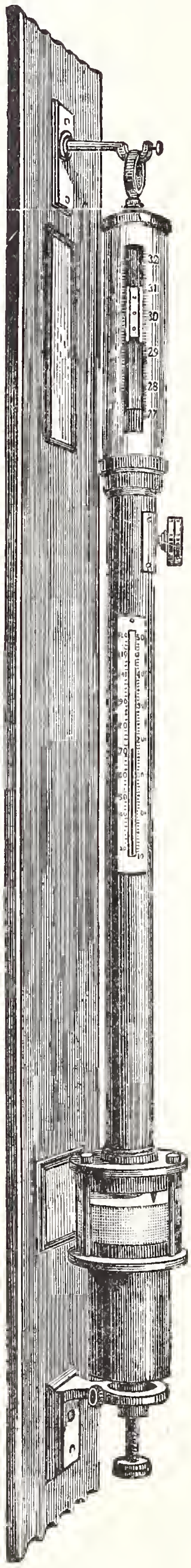


Fig. 7.

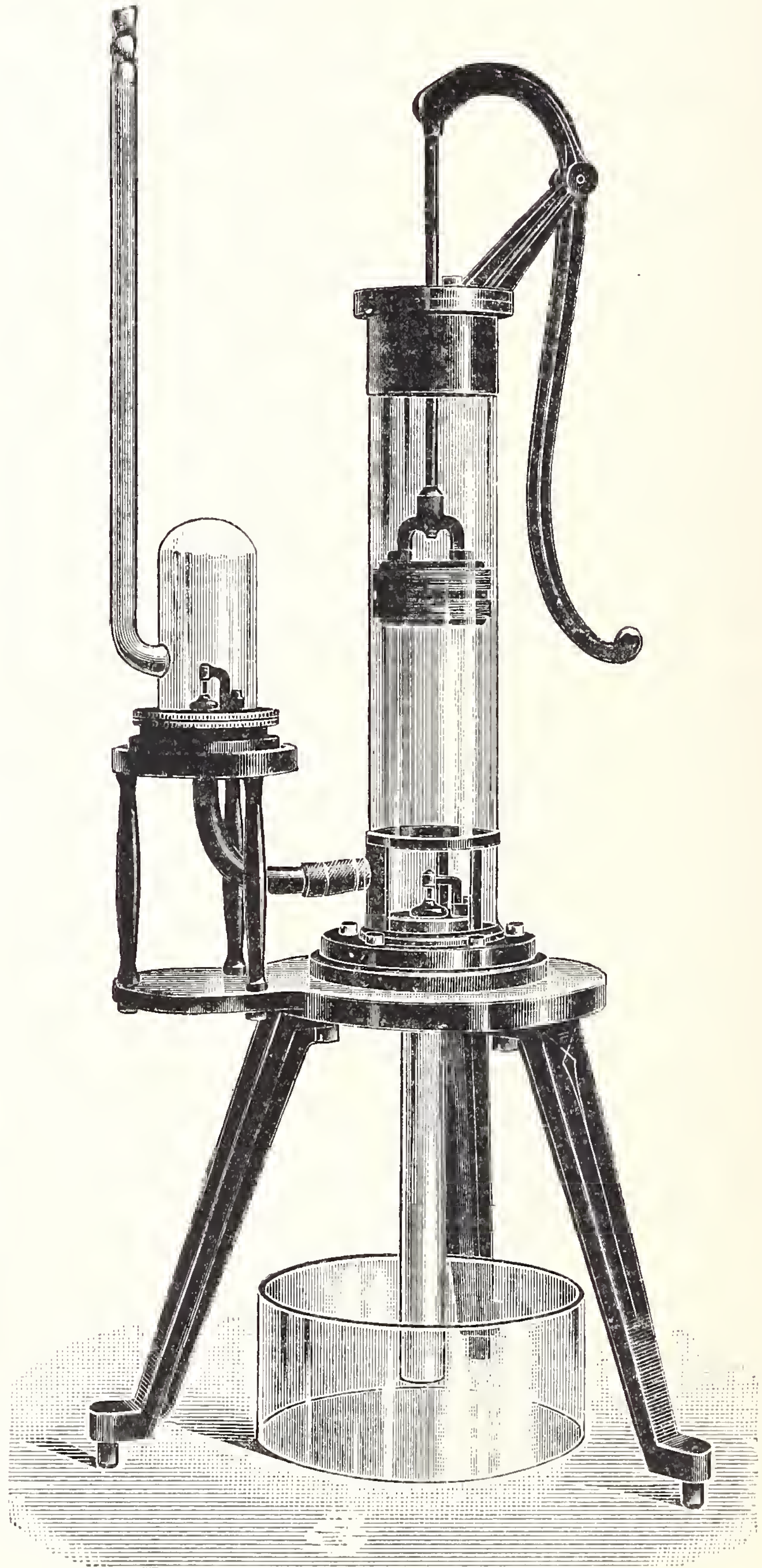


Fig. 8.

8. Model of a Force Pump. Fig. 8. The dimensions of this model are such as to clearly show the action of the pump, and the movements of the valves can be followed with great ease.

9. Model of a Suction Pump. Fig. 9. This model is fitted with large parts and appropriately constructed valves so as to clearly demonstrate the action of the pump.

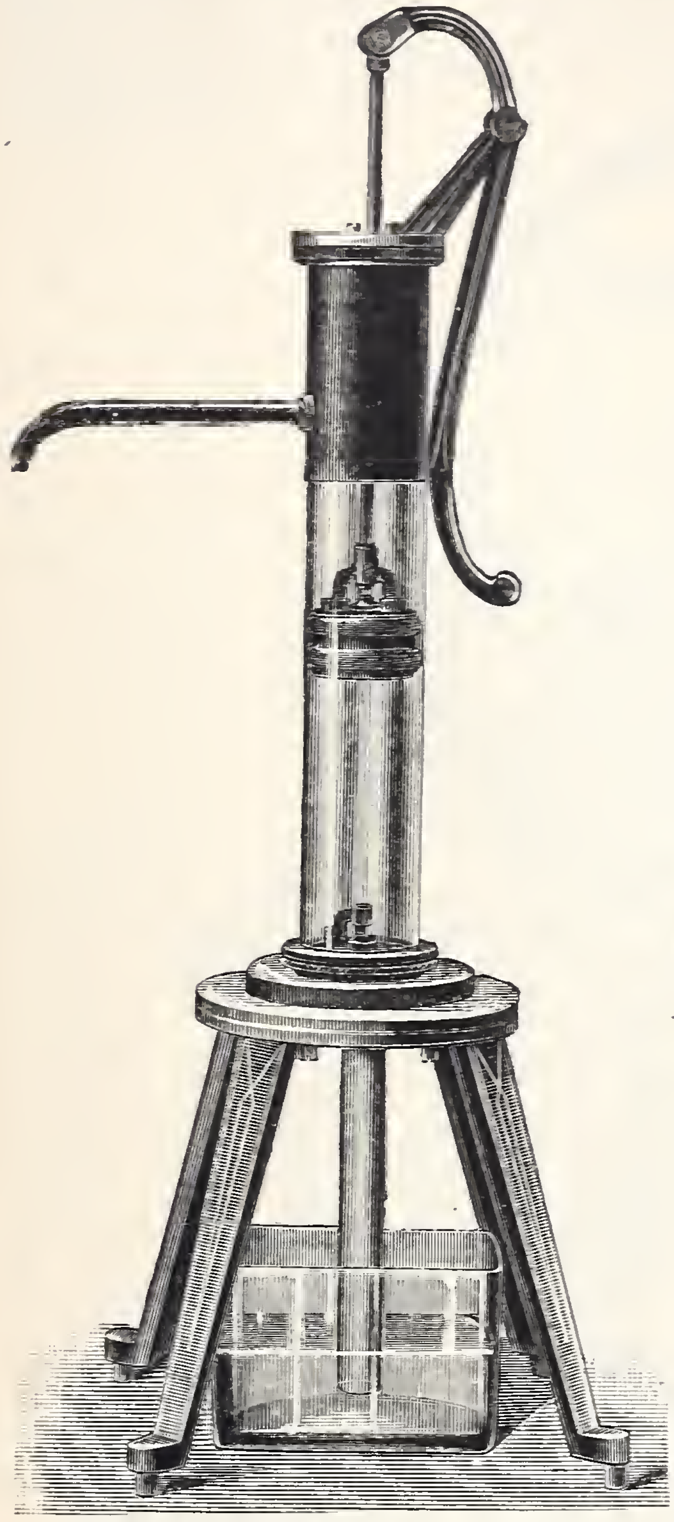


Fig. 9.

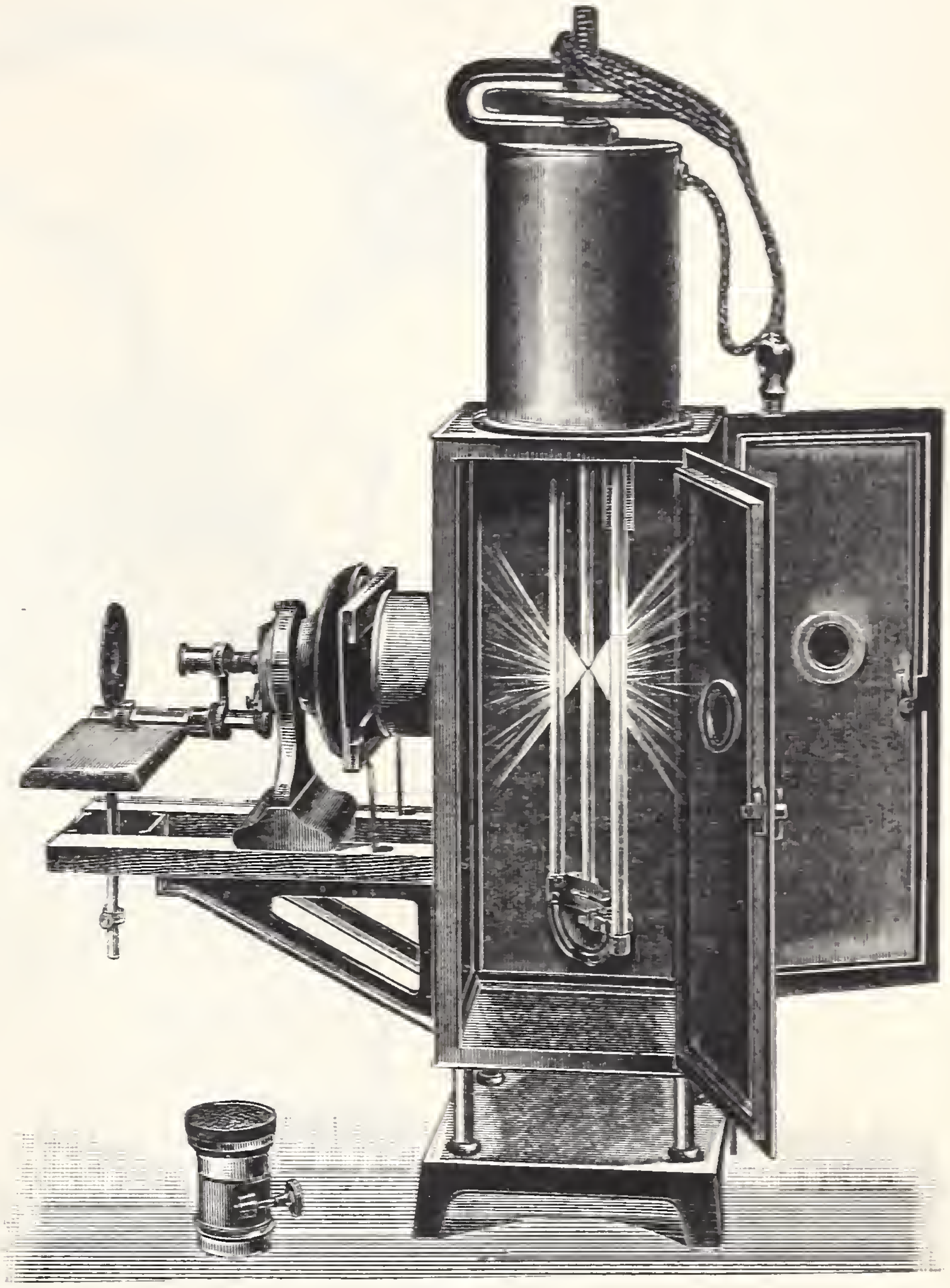


Fig. 10.

10. Projection Lantern for Electric Light. Fig. 10. This lantern is fitted with an automatically regulating arc-lamp for continuous or alternating currents. The luminous point can be centred by means of a bevelled head. The lantern is fitted with a short detachable optical bench for the projection head and the objects which are to be shown on the screen.

11. Bianchi's Air Pump. Fig. 11. The barrel of this pump being of glass is not liable to oxidation while not in use. It is double acting and fitted with a Babinet cock. Both valves, in contradistinction to older types, are placed outside the barrel so as to facilitate the process of cleaning. The pump produces a vacuum of 2 mm on the mercurial pressure gauge. The plate is fitted with electrodes communicating with the interior of the receiver.

12. Air Pump with Two Barrels. Fig. 12. The barrels are of glass so as to obviate oxidation when the pump is not in use. The valves are situated outside the barrels and can easily be cleared. The plate has a diameter of 250 mm. The pump is fitted with a Babinet cock and reduces the pressure in a very short time to 2 mm.

13. Helmholtz's Double Syrene, driven by an electromotor of adjustable speed. Fig. 13. This apparatus is adapted for determining the number of vibrations of single sounds, for producing chords, beats and compound tones. When thrown into gear the counting apparatus closes an electric current which causes an electric clock to beat seconds.

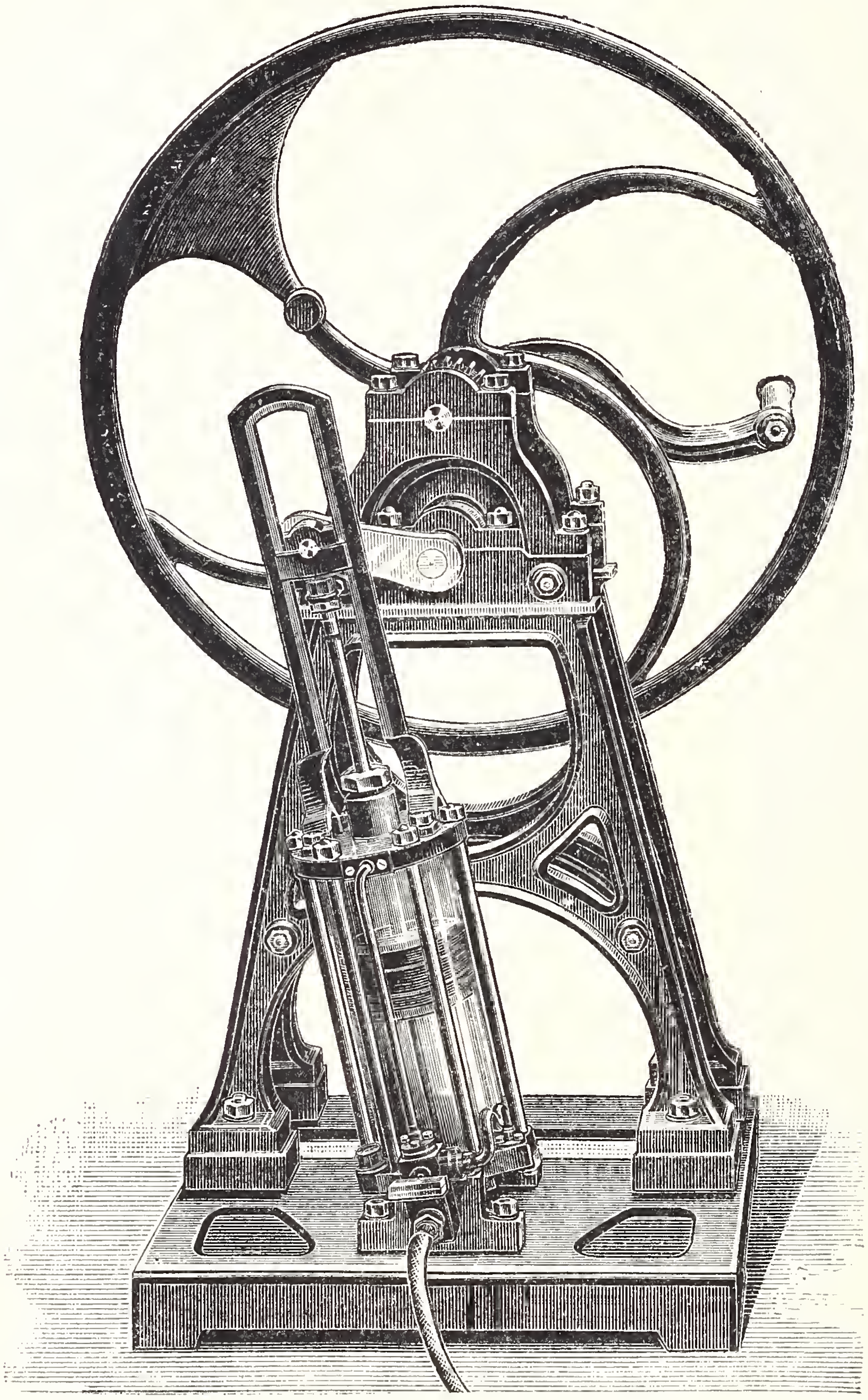


Fig. 11.

14. Helmholtz's Tuning Fork Apparatus for producing Lissajous's curves and for graphically demonstrating the vibrations of two tuning forks. Figs. 14 and 15. The forks are intoned by electromagnets and can be made to vibrate in a vertical or horizontal plane. The curves may be shown by reflection at carefully polished steel mirrors attached to the legs as well as by tracings. The apparatus includes a set of forks fitted in an elegant case.

15. Small Stand with Seven Tracings made by the preceding apparatus, for demonstration on the screen. Fig. 16. The curves exhibit the following phase differences: 1 : 2, 2 : 3, 3 : 4, 4 : 5, 3 : 5, 5 : 6 and 35 : 36.

16. **Paul La Cour's Phonic Wheel.** Fig. 17. The phonic wheel consists of a hollow wooden drum having attached to its circumference 20 soft iron armatures rotating in front of a horse-shoe electromagnet excited by a current which is rendered intermittent by a tuning fork. Continuous rotation is established as soon as the speed is such that the armatures pass the electromagnets at the same rate that the circuit is closed. The periodicity of the fork can then be ascertained by the counting dials.

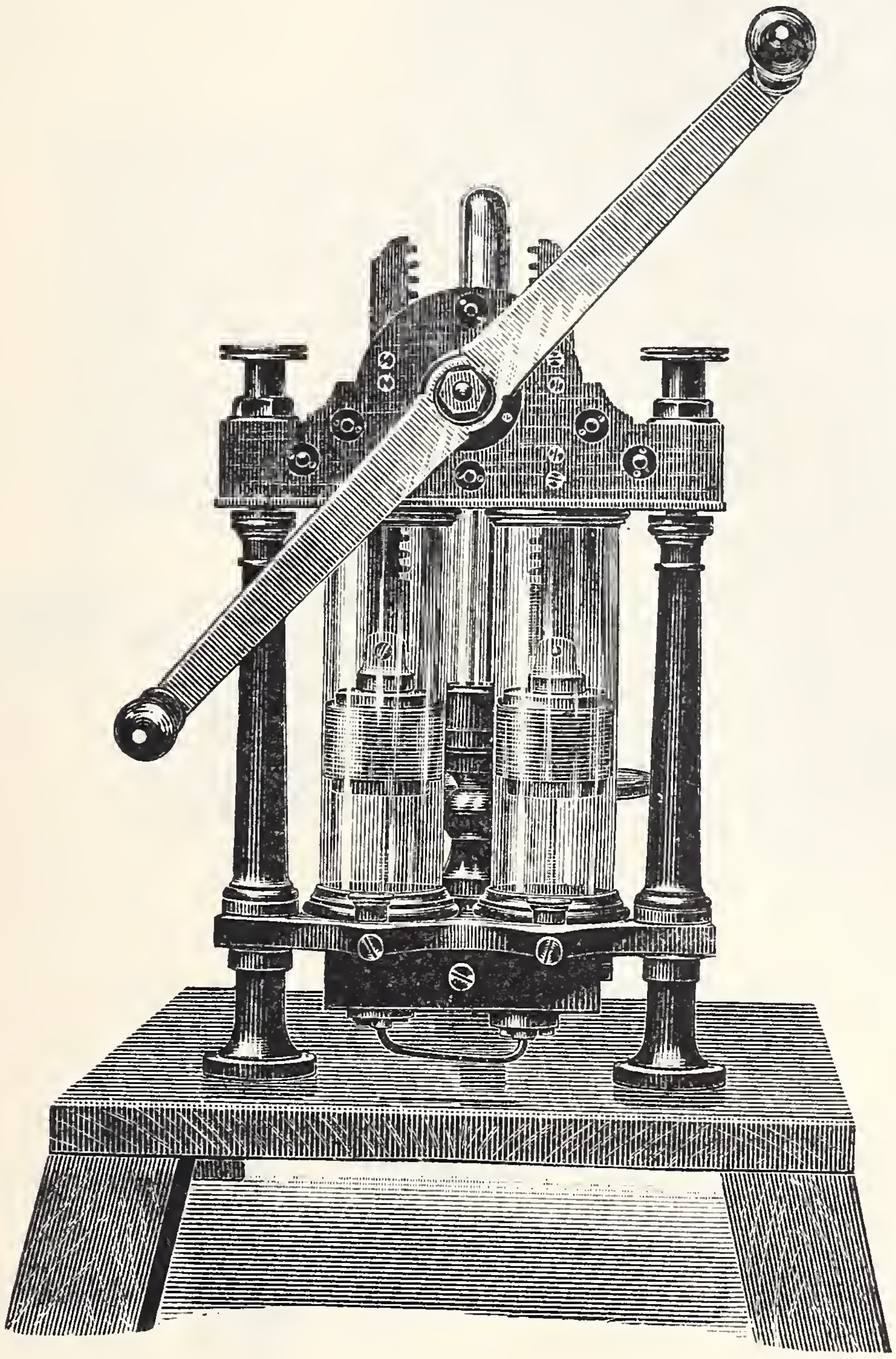


Fig. 12.

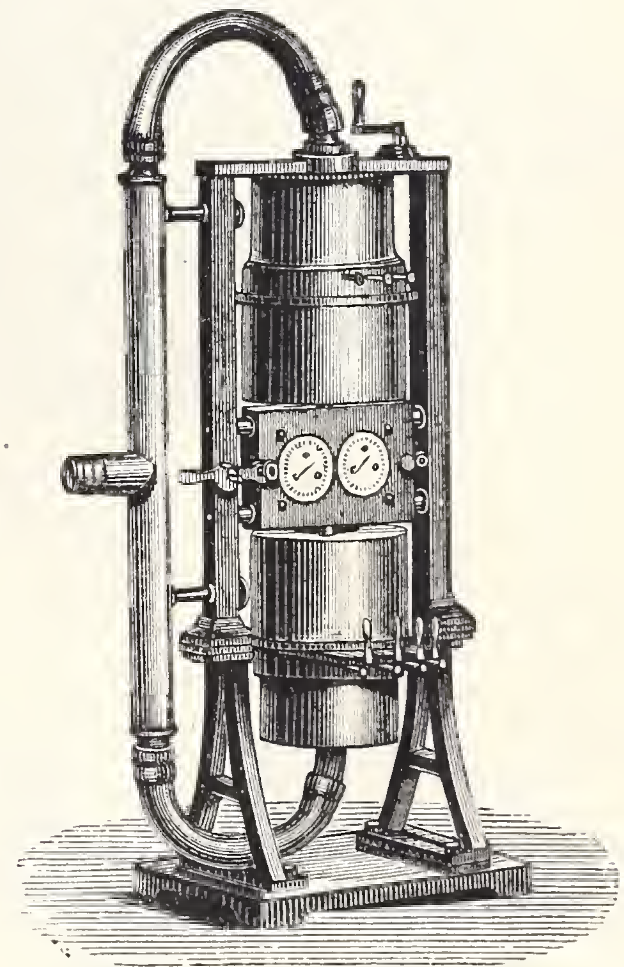


Fig. 13.

17. **Weinhold's Demonstration Goniometer.** Fig. 18. The goniometer can be used in a horizontal and vertical position as a means for demonstrating the laws of reflection, refraction and dispersion, for determining angles of prisms and refractive indices; it is available as a goniometer and spectrum apparatus, and for spectrometric experiments and spectrum analysis. The accessories include a centreing stage for crystals, a mounted plane mirror, a water vessel with slit, a slit with illuminating mirror, an index, two lenses, a collimator tube, a telescope, a prism of heavy flint glass having sides of 45 mm and a spanner. All these parts are contained in an elegant case.

18. **Bruno Kolbe's Refraction Apparatus,** Fig. 19, for experiments on reflection at plane mirrors, refraction of light when passing into a denser medium and conversely (air-glass, glass-air, water-air, &c.), total reflection, refraction in parallel glasses, minimum deviation, refraction in prisms and lenses, reflection at cylindrical mirrors, &c.

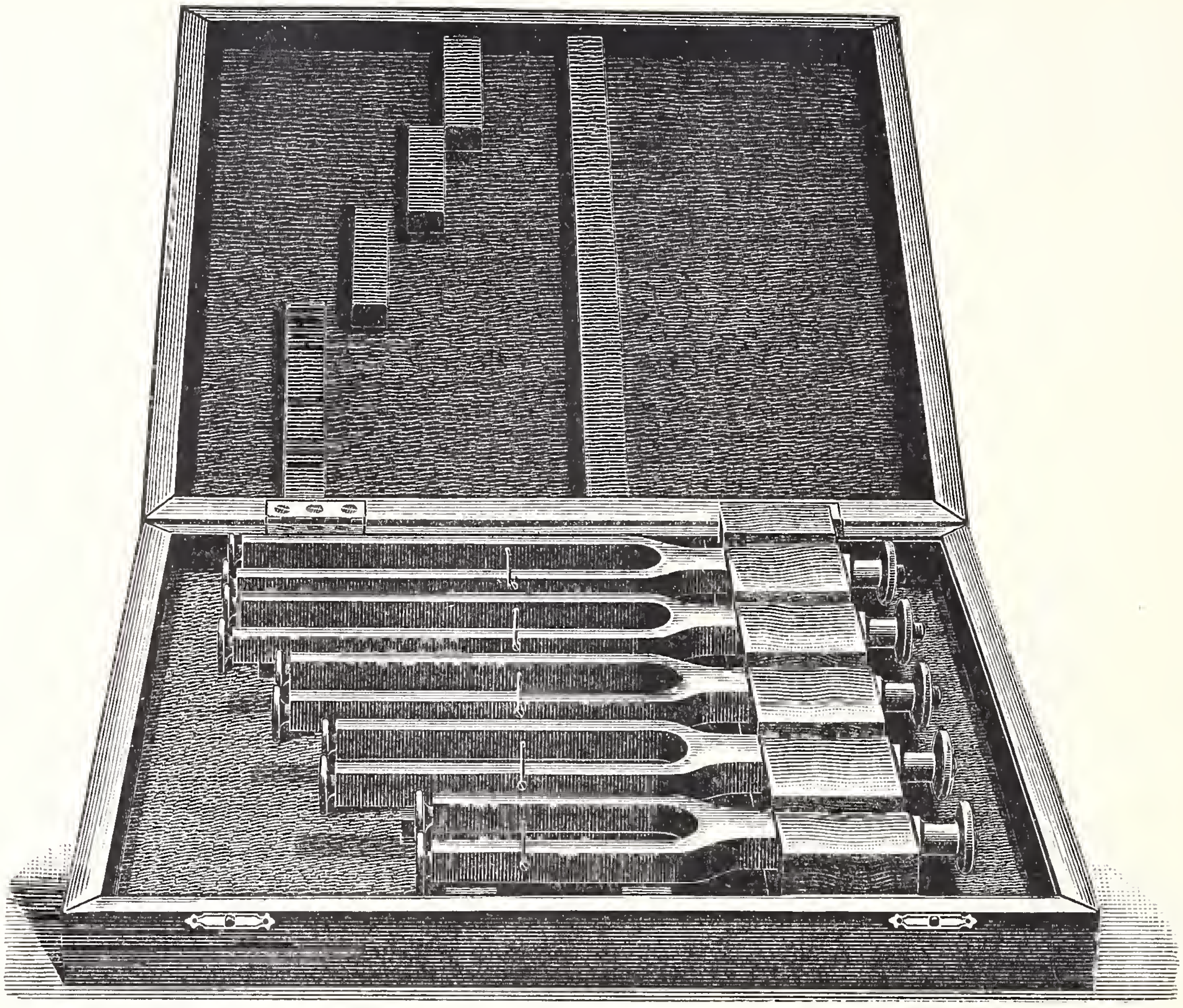


Fig. 14.

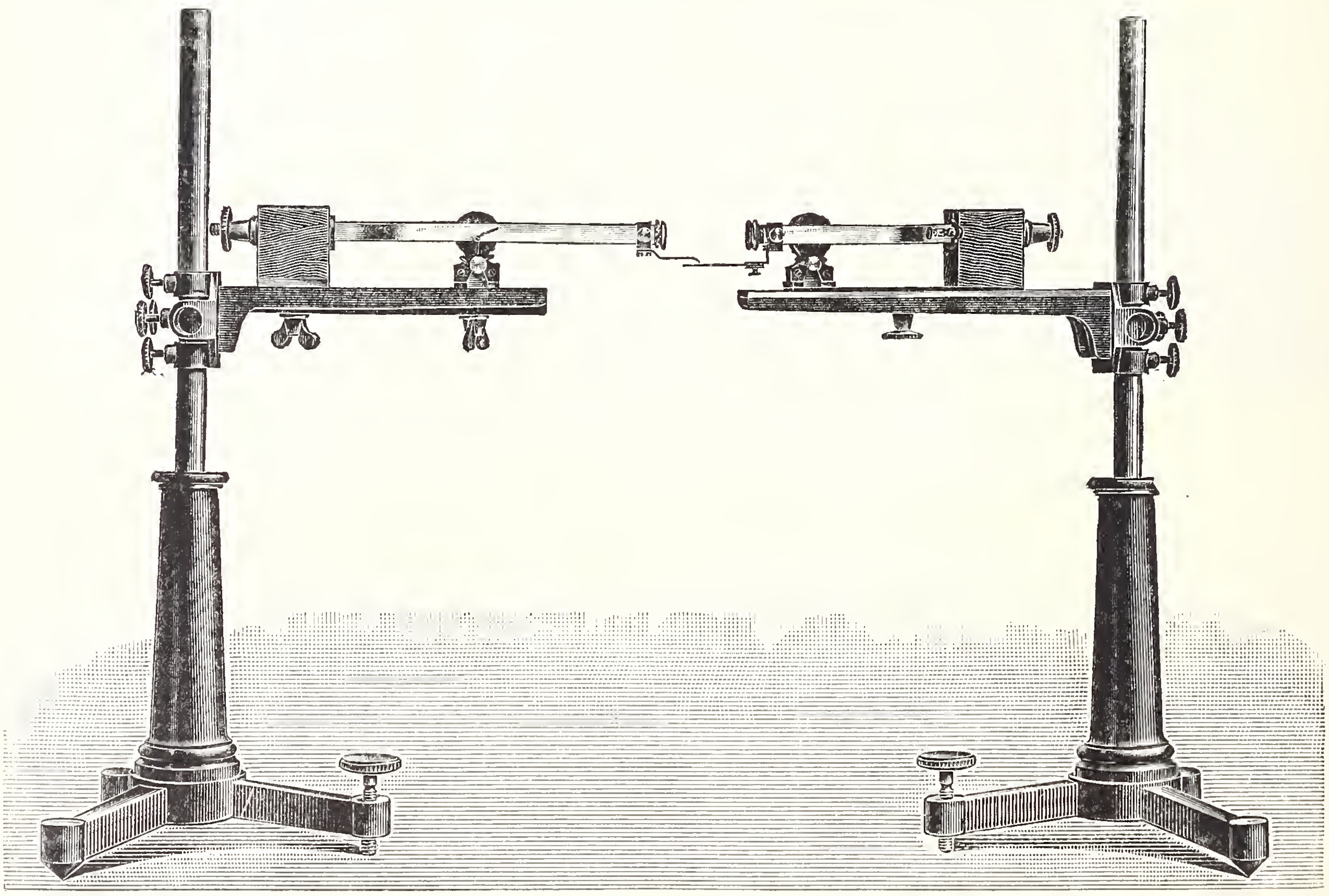


Fig. 15.

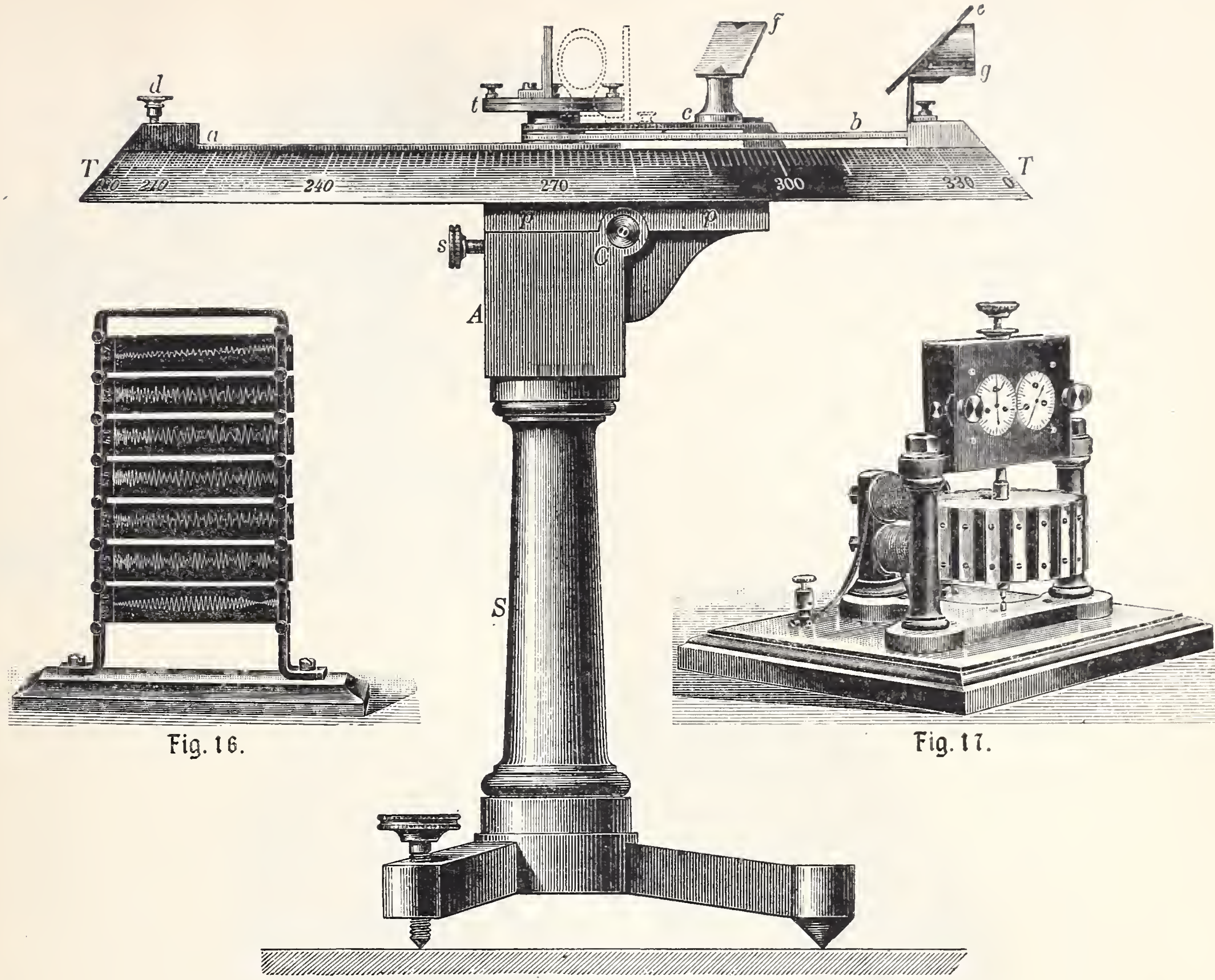


Fig. 16.

Fig. 17.

Fig. 18.

19. Lens Stand, Fig. 20, adapted as a holder for unmounted lenses of various diameters, concave as well as convex. The lenses can be raised or lowered.

20. Model of a Theodolite, Fig. 21, with vertical and horizontal circles, the latter being adapted for repetition. The circles are divided into 360° and read to $^1/_{10}$° by verniers. The eyepiece is adjustable by rack and pinion and is fitted with a prism and sun-glass for astronomical observations.

21. School Spectrum Apparatus. Fig. 22. The apparatus is equipped with a heavy flint prism of 60° having a dispersion of 7°, a slit collimator and telescope having an aperture of 27 mm and a scale and comparison prism.

22. Polarizing Apparatus. Fig. 23. This apparatus is fitted with a powerful system of lenses for magnifying the axial images and has an exceptionally large field. The poles of the rings in sulphite of sodium can both be seen simultaneously.

23. Prof. Dr. Friedr. C. G. Müller's Heliostat. Fig. 24. This new heliostat possesses the great advantage of being very easily set up. The edge of the lower frame is placed parallel to the meridian, the heliostat is then levelled by means of the elevation screws, and the plumb-bob and the hands of the clock are set to time. The upper mirror is then inclined so as to cause the centre of its pencil of rays to fall upon the lower mark. Cross wires are clamped upon the upper mirror for finding the centre of the pencil. When the position of the lower mirror is such that the pencil of rays falls into the room the adjustment of the instrument is complete.

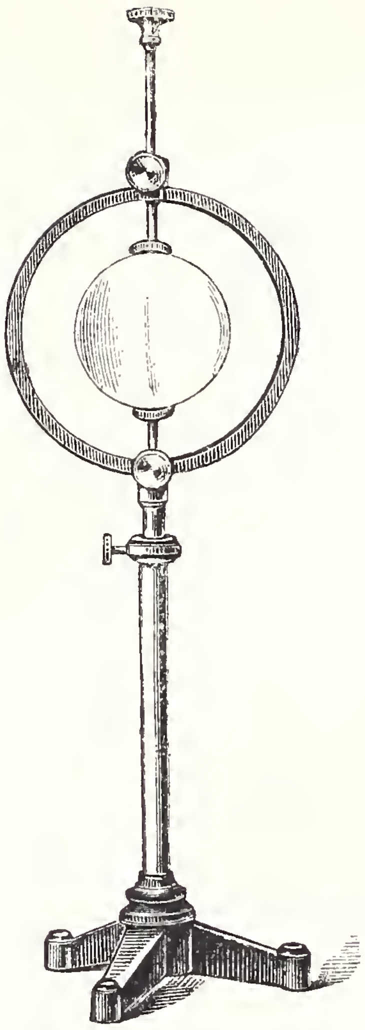


Fig. 20.

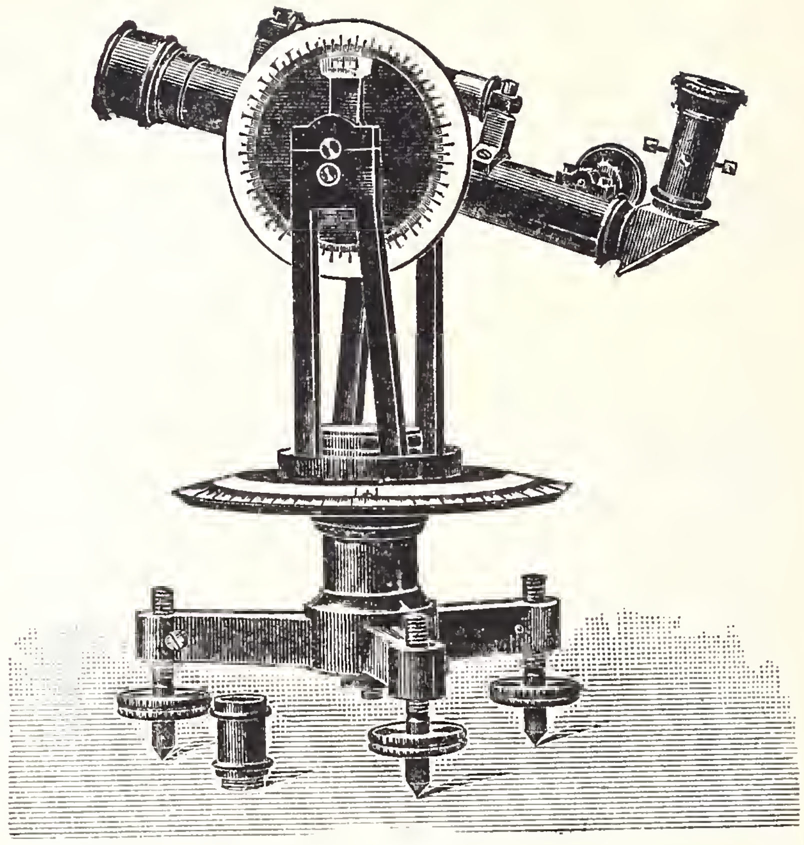


Fig. 21.

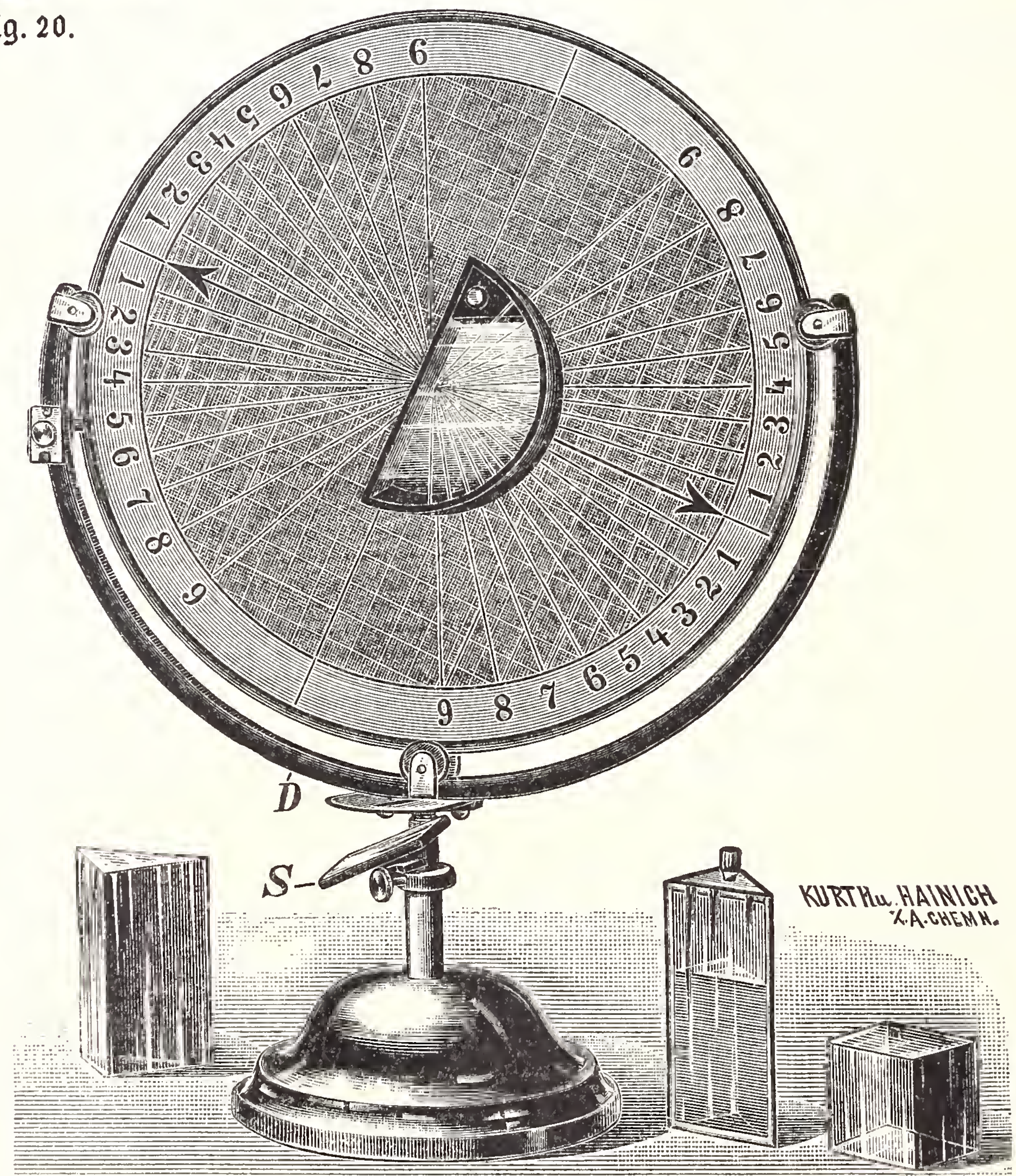


Fig. 19.

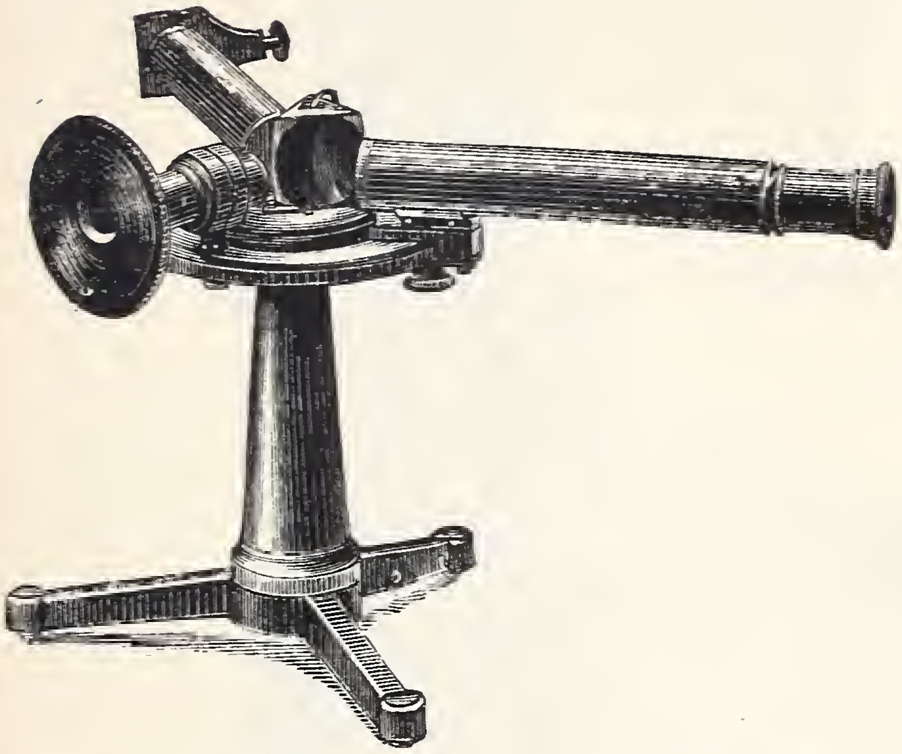


Fig. 22.

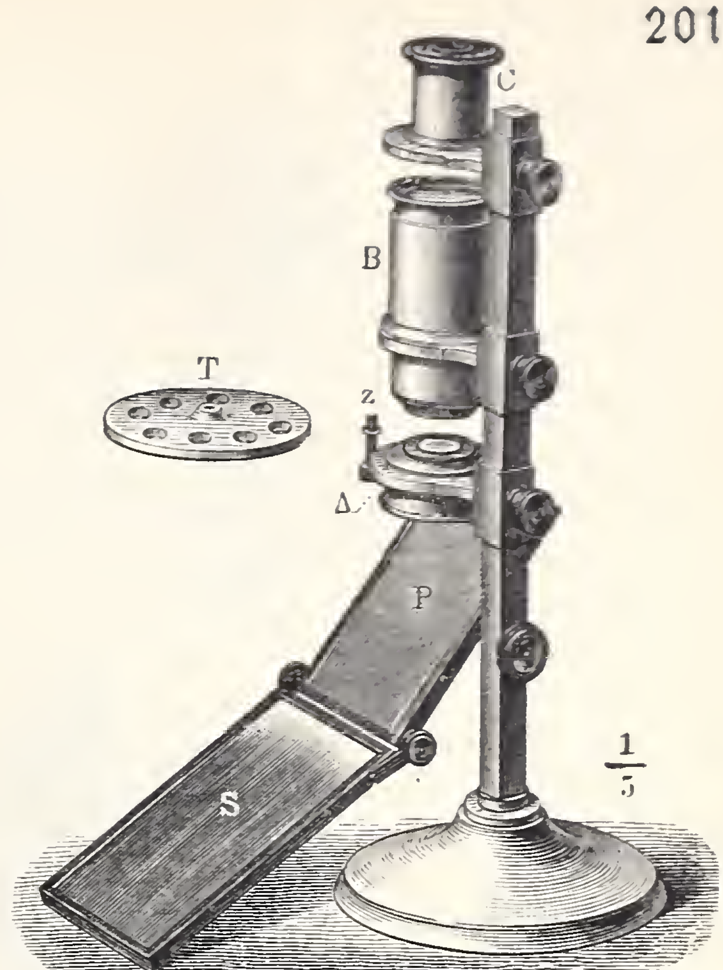


Fig. 23.

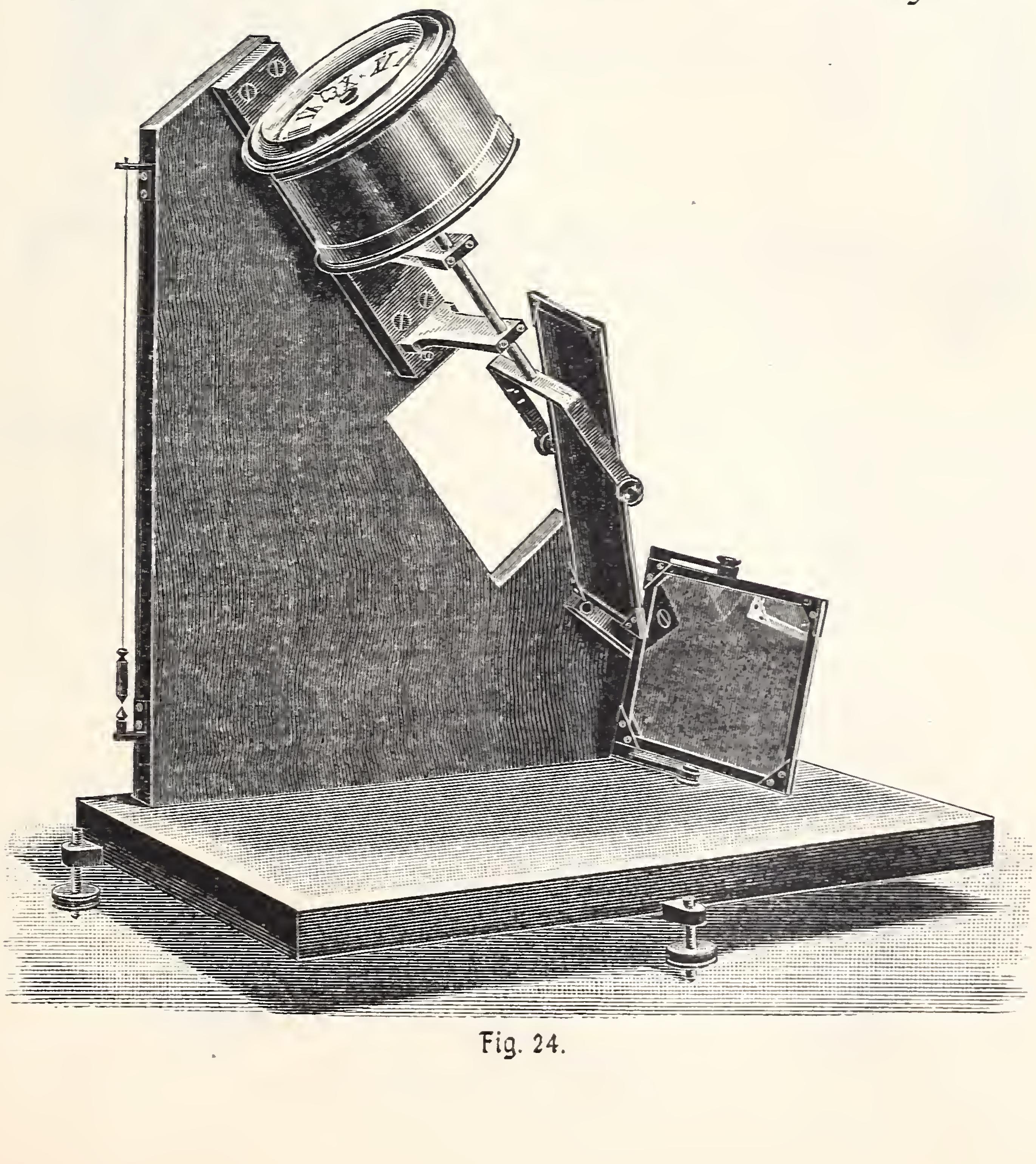


Fig. 24.

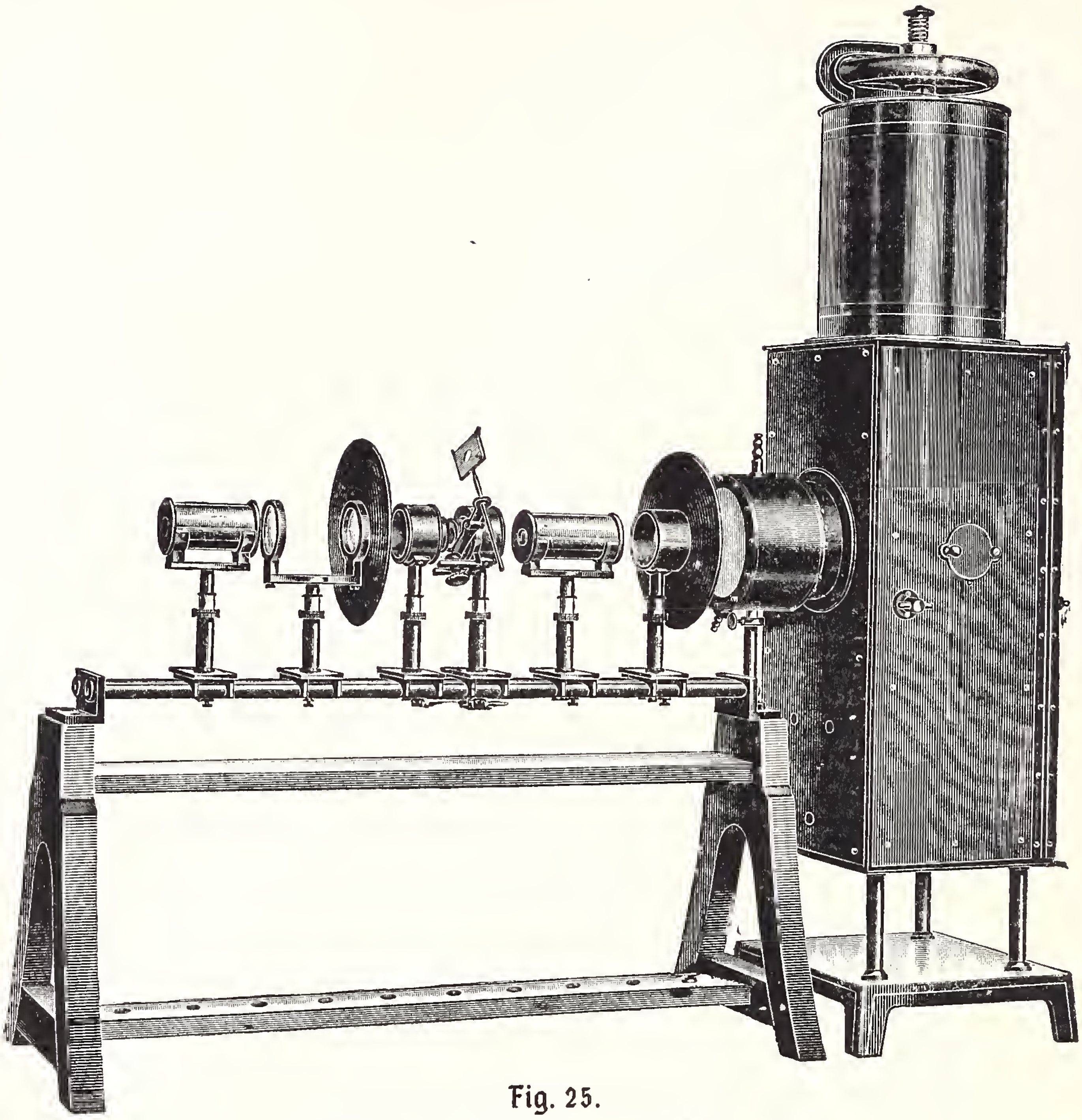


Fig. 25.
Arrangement for polarization in convergent light.

24. Prof. Paalzow's Optical Bench. Figs. 25 to 30. This apparatus is adapted for the following experiments:—

1. Double refraction and polarization in parallel and convergent light.
2. Demonstration of spectrum phenomena.
3. Demonstration of microscopical phenomena. These are readily understood as the path of the rays can be followed throughout. The apparatus is equipped with all requisite accessories, viz. Nicol prisms, set of glasses, black mirror, condensers, &c.

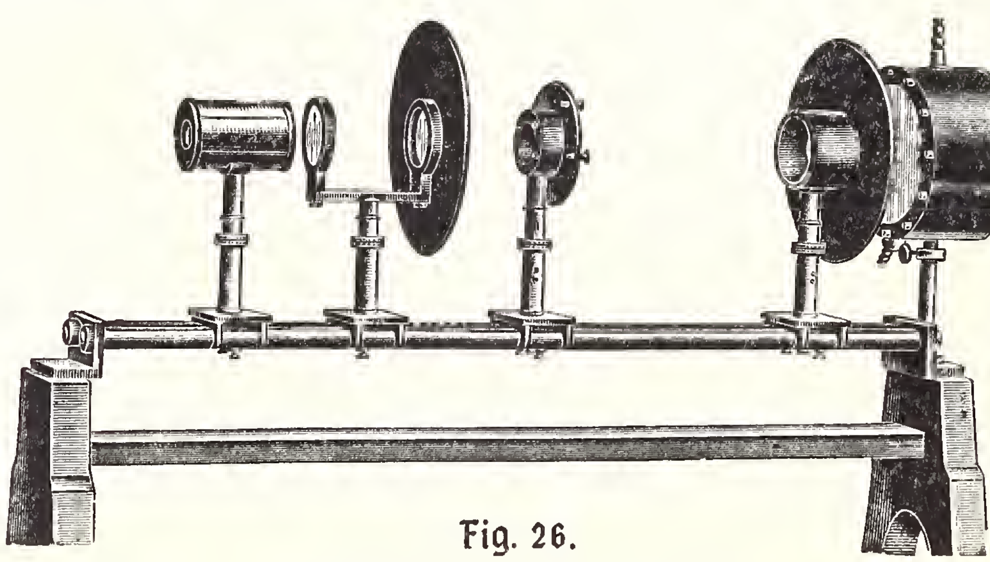


Fig. 26.
Arrangement for double refraction.

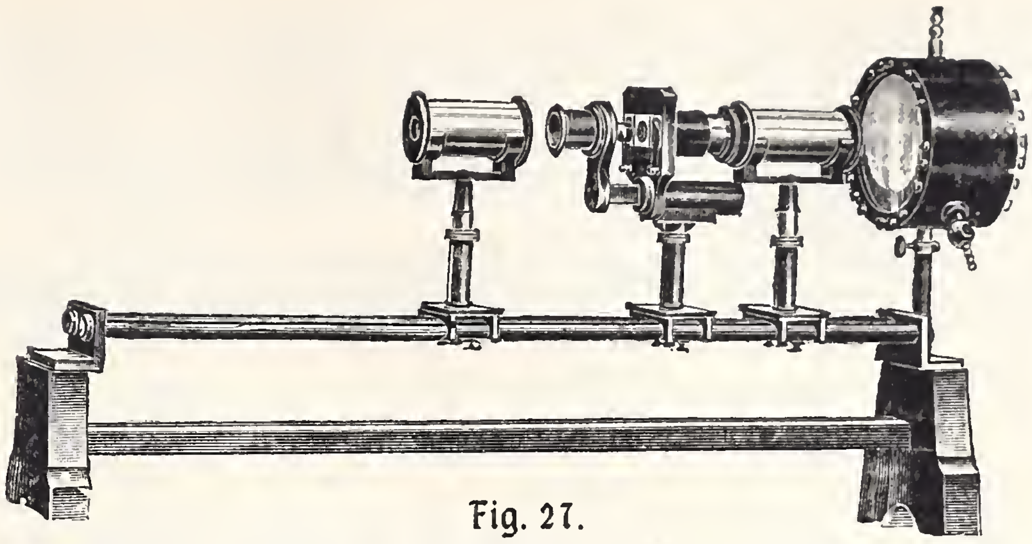


Fig. 27.
Arrangement for demonstrating microscopic phenomena in polarized light.

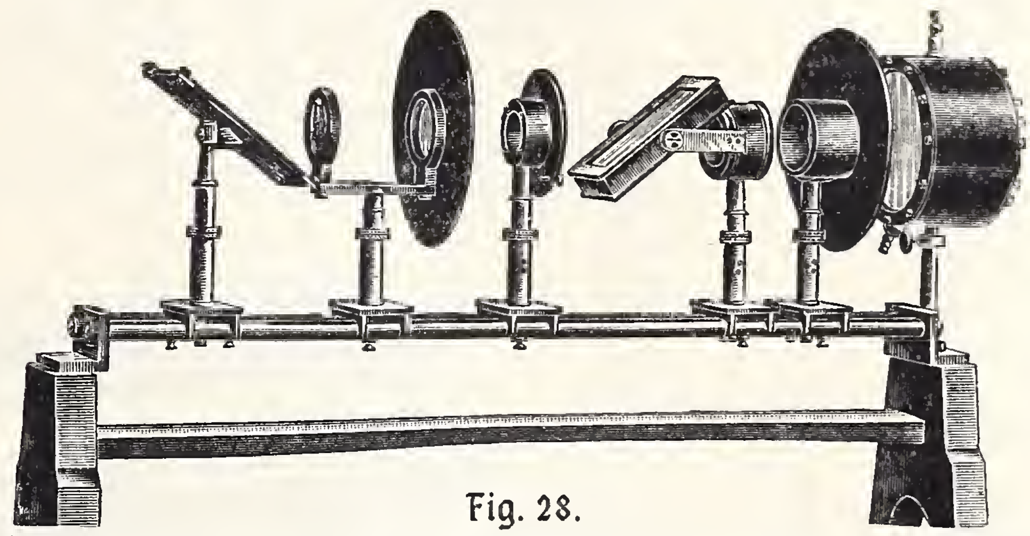


Fig. 28.
Arrangement for polarization with column of glass plates and black mirror.

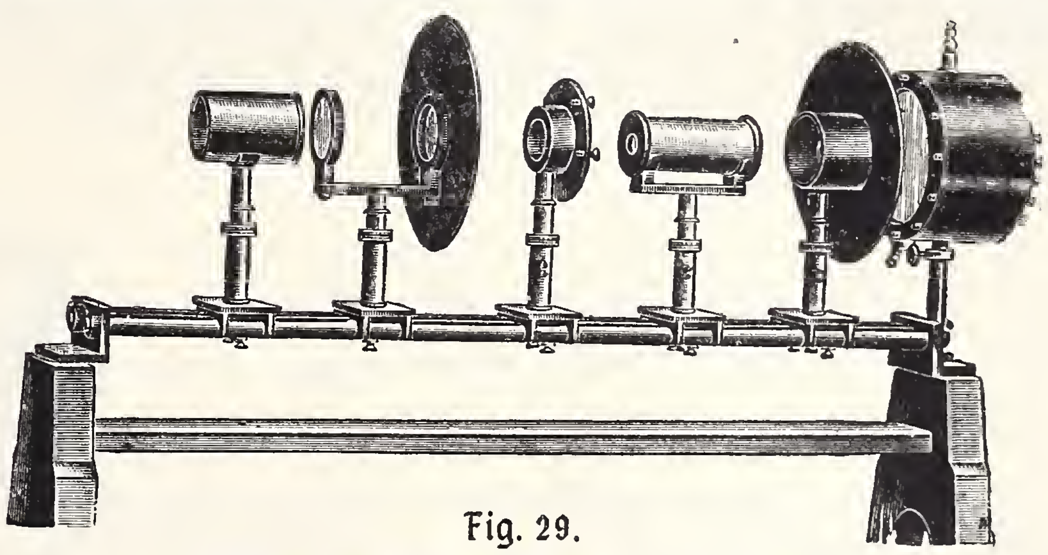


Fig. 29.
Arrangement for polarization in parallel light.

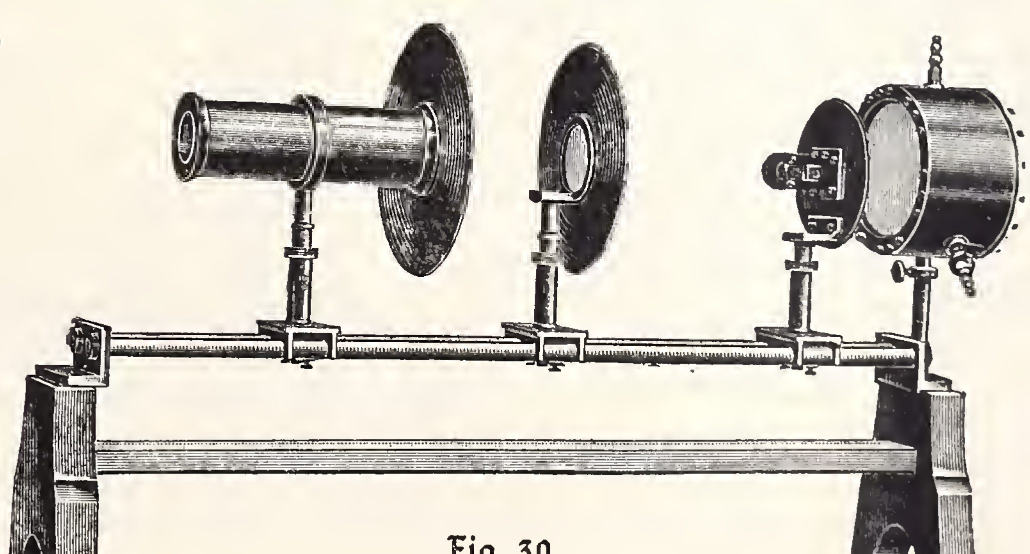


Fig. 30.
Arrangement for spectrum phenomena.

25. Apparatus for Ascertaining the Density of Steam by Dumas's method. Fig. 31. A sufficient quantity of the fluid under examination is evaporated in bulb A so as to completely fill it with vapour but no fluid should remain in the bulb. The latter is then closed. The quantity of vapour is then ascertained by weighing, allowance being made for the air displaced by the vapour whence the quantity can be found which the bulb would contain at 0° C. at a pressure of 760 mm. The capacity of the bulb is ascertained by weighing.

26. Model of Molecular Magnet suggested by von Beetz for experimentally demonstrating the Amperian theory. Fig. 32.

27. Dipping Apparatus with Reversible Needle. Fig. 33.

28. Bruno Kolbe's Electrometer. Fig. 34. This electrometer has a mica quadrant divided into degrees and interchangeable against another scale graduated in terms of volts. The electrometer casing is made of metal and can be connected to earth. The front and back are glass pannelled so as to render the instrument available for projection on the screen. The aluminium foil is sus-

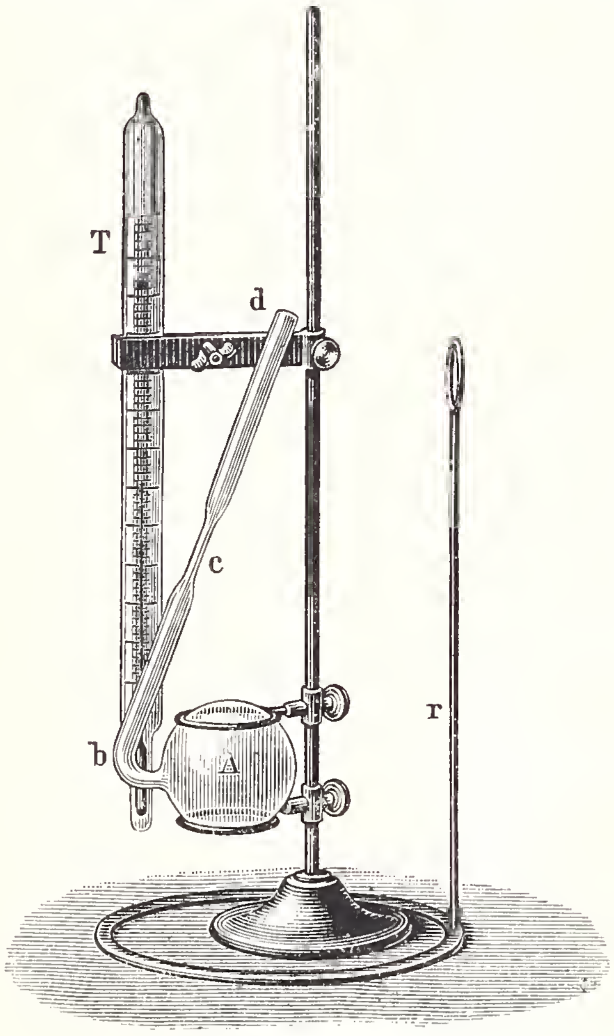


Fig. 31.

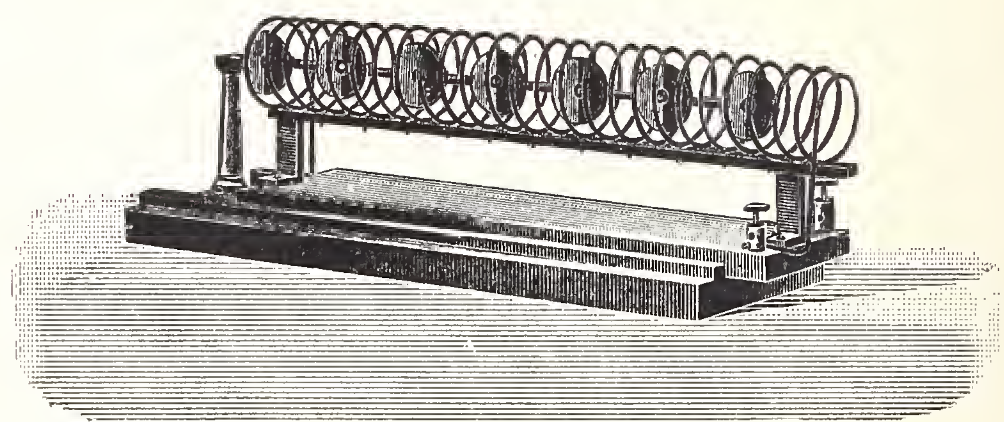


Fig. 32.

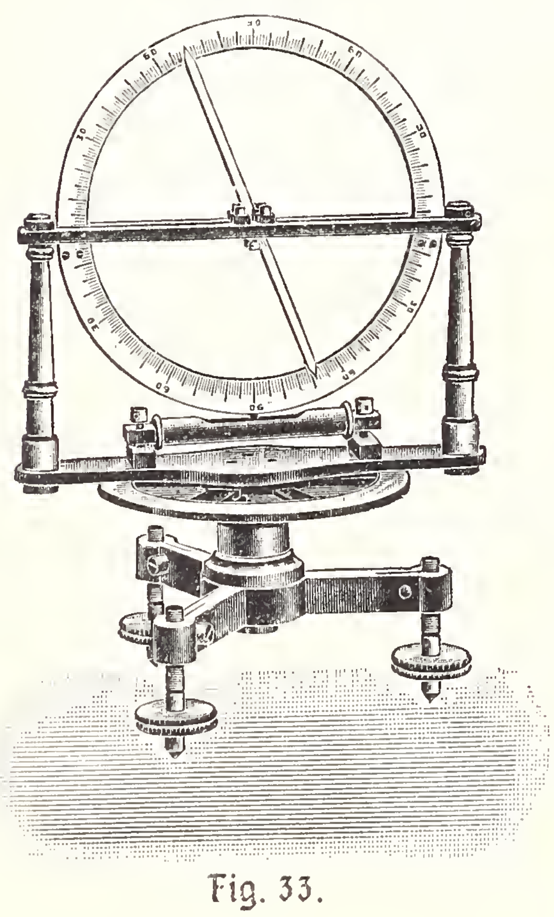


Fig. 33.

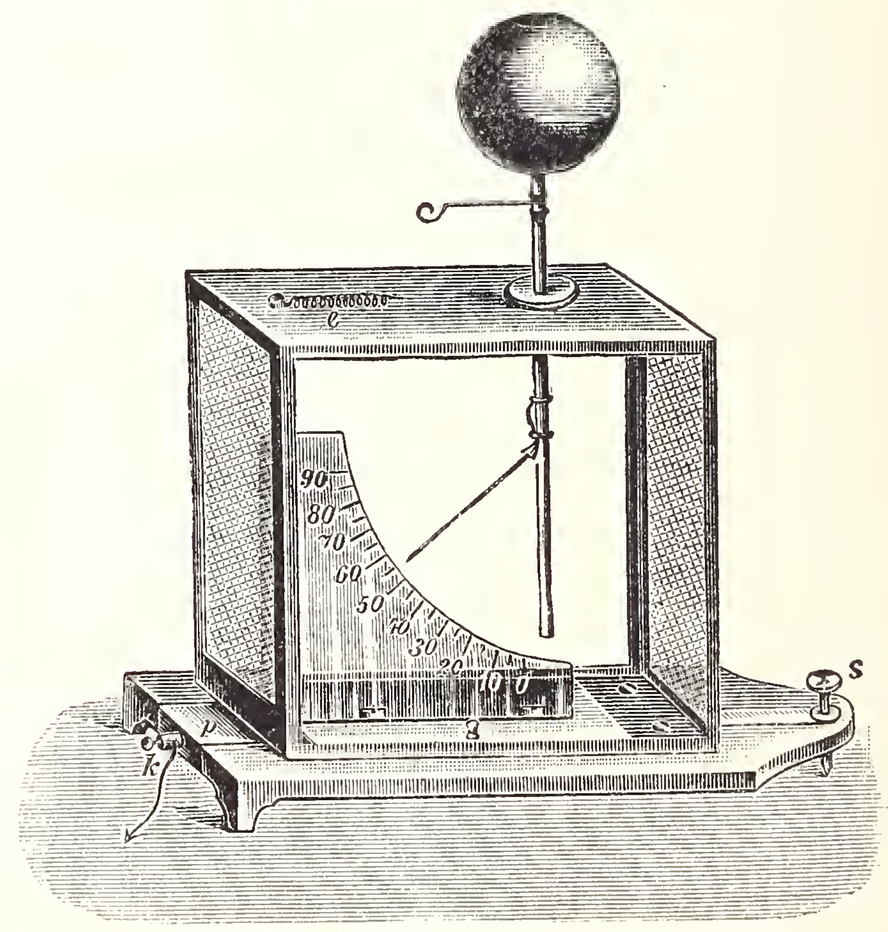


Fig. 34.

pended by a peculiar method which renders the electrometer extremely sensitive. The condenser can be replaced by a hollow sphere, and an ebonite plug with a paper strip can be substituted for the plug with aluminium foil.

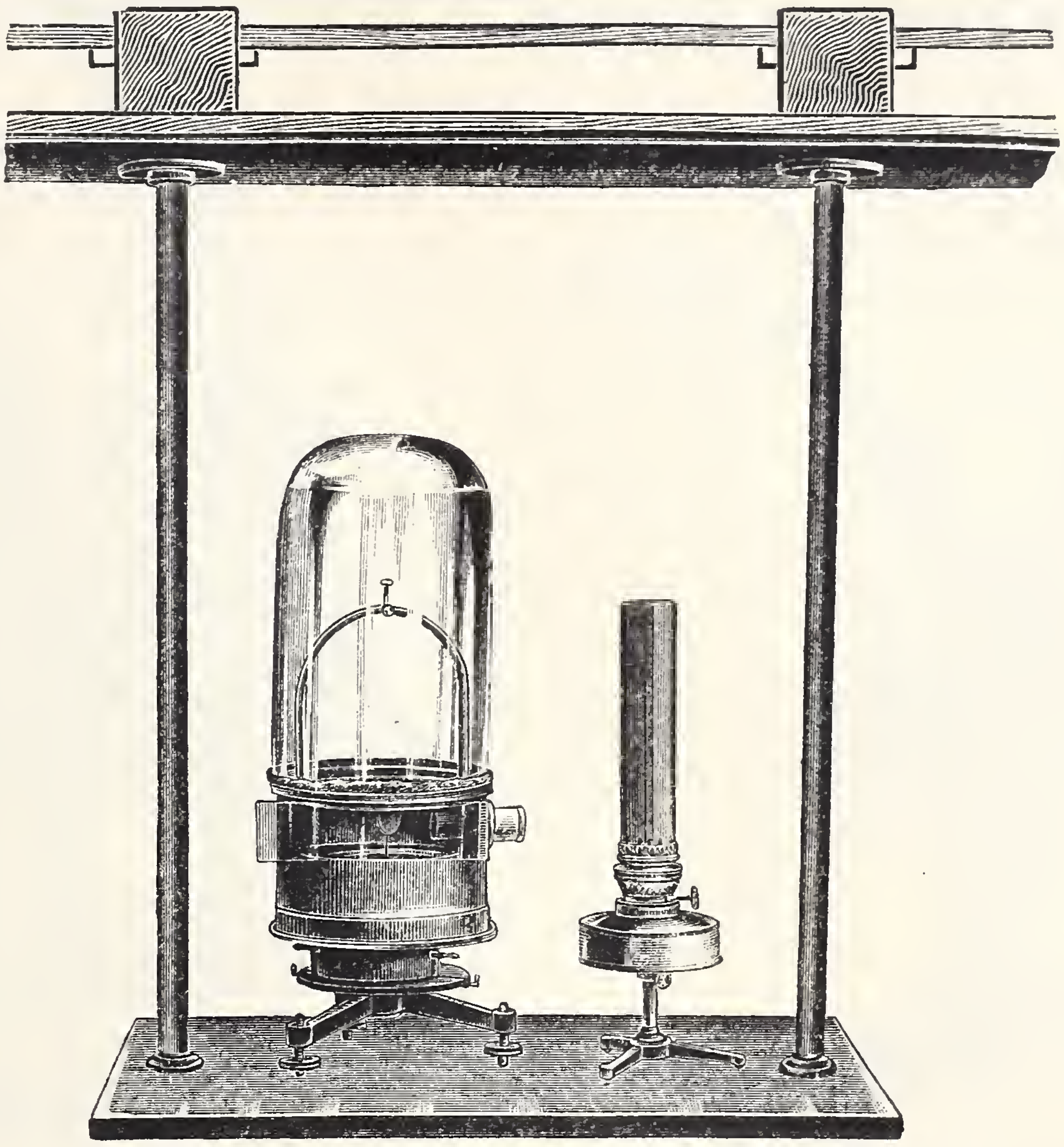


Fig. 35.

29. Weinhold's Reflecting Galvanometer. Fig. 35. This instrument is fitted with Töpler's adjustable air damping arrangement, an astatic needle and dial pointer, an excellent mirror for reflection on the scale, outer case with lens and a bobbin having wound upon it two separate wires 1 mm thick (having a resistance of about 1.5 ohms) and two sections of wire 0.2 mm thick (having a resistance of about 1000 ohms). The ends of both coils are joined to three terminals which are connected with three binding screws situated near the experimenting table by three wires having a thickness of 2 mm. By reason of this arrangement either the coarse or fine winding can be used without in any way altering the galvanometer. The exact resistances of the two coils are noted on their respective bobbins. The galvanometer together with the lamp is placed upon a bracket suspended from the ceiling, the scale being mounted on the opposite wall.

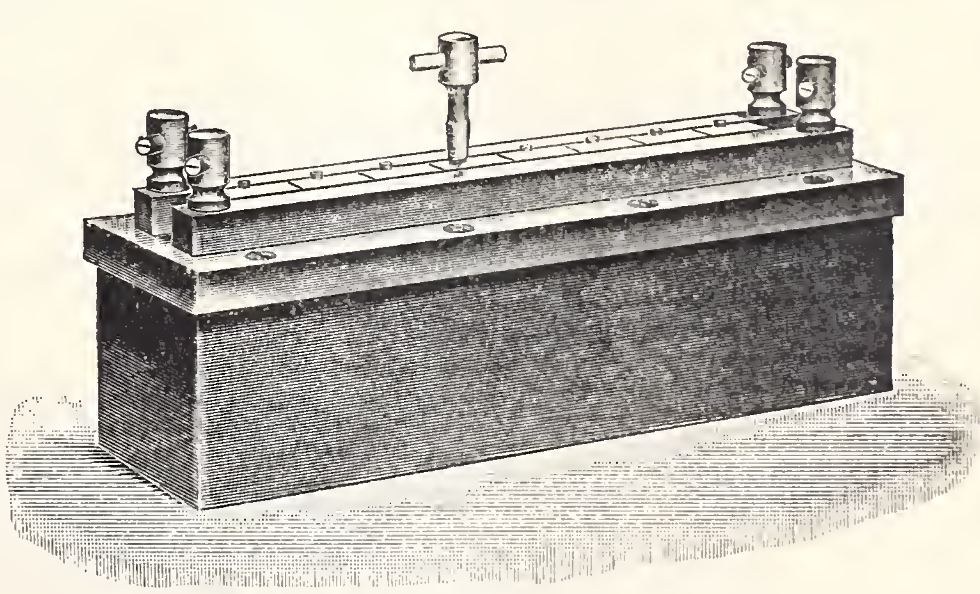


Fig. 36.

30. Shunt for the Reflecting Galvanometer. Fig. 35. The resistances are so calibrated as to allow 0.3, 0.1, 0.03, 0.01, 0.003, 0.001 of the current which is to be measured to pass through the galvanometer.

31. Vertical Galvanometer. Fig. 37. The magnet rests with its steel knife-edges upon steel bearings. The coil is wound in two sections, one consisting of stout wire for thermo-electric currents, the other of thin wire for measuring resistances. The coil can be raised and lowered so as to regulate the degree of sensitiveness. The pillar turns on the tripod and can be fixed by a clamping screw. Both scale and pointer can be seen a long way off.

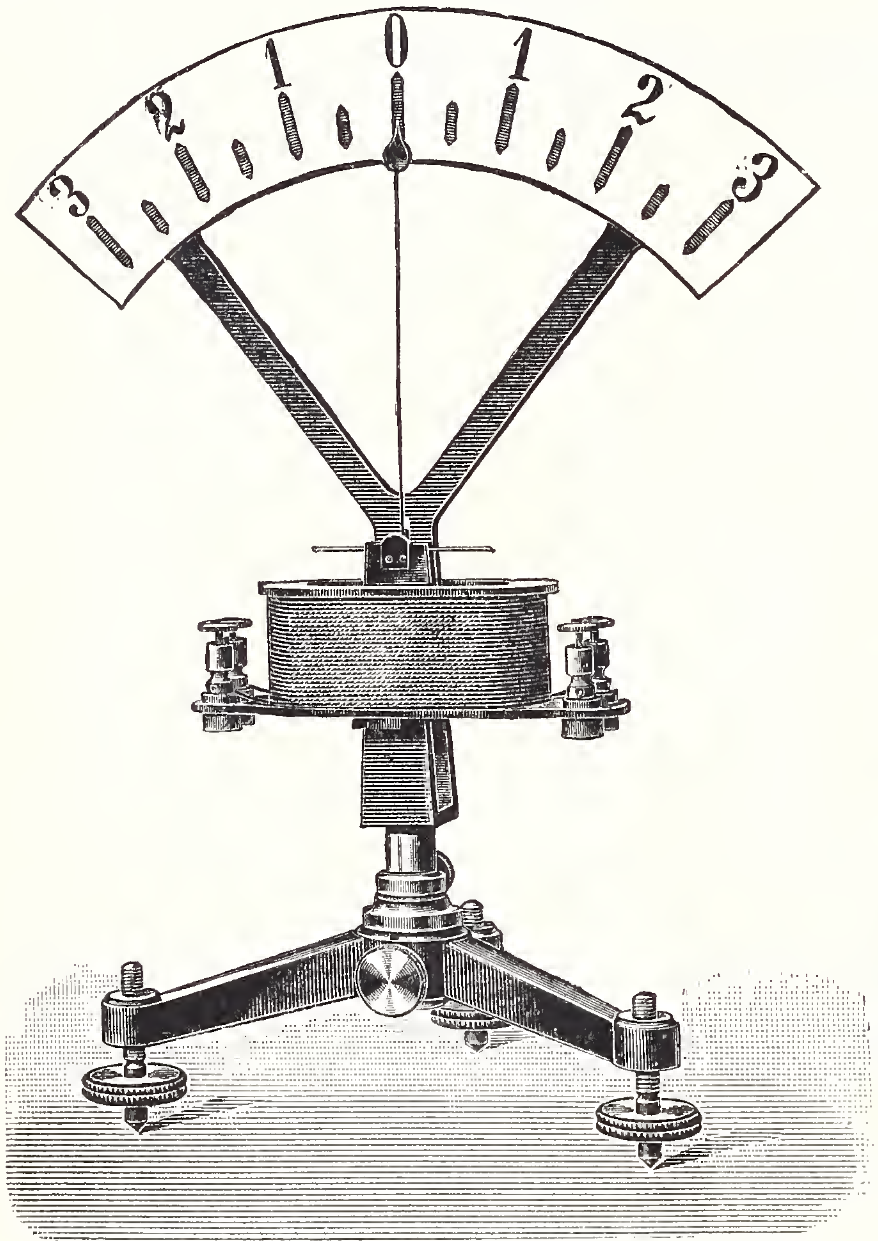


Fig. 37.

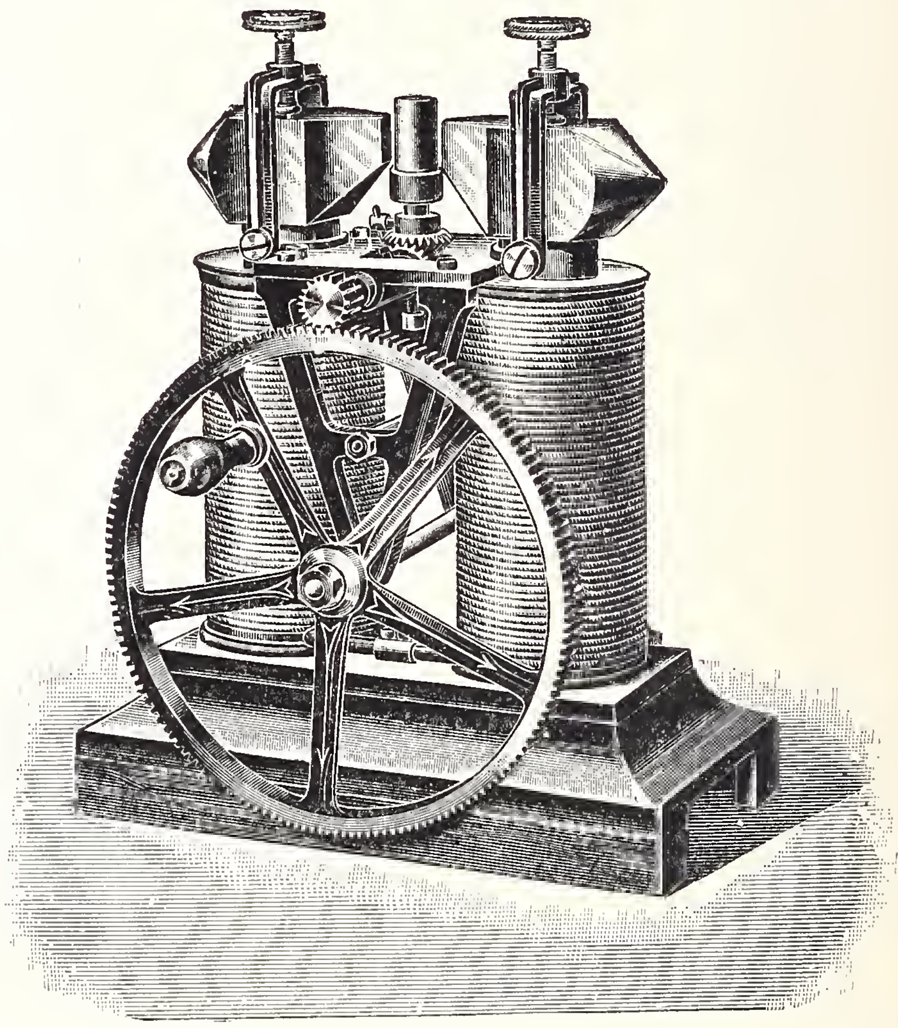


Fig. 38.
Arrangement for fusing metal in the magnetic field.

32. Electromagnet for all electro-magnetic and diamagnetic experiments. Figs. 38 to 41. This electromagnet is available for experiments on the behaviour of diamagnetic and paramagnetic bodies, rotation of the plane of polarization, separation of the aureole and sparks, diamagnetism of flames, the damping action of electric induction (Waltenhofen's pendulum), heating effect of Foucault currents, the generation of Foucault currents, as demonstrated by Foucault's disk and Tyndall's rotating coin apparatus.

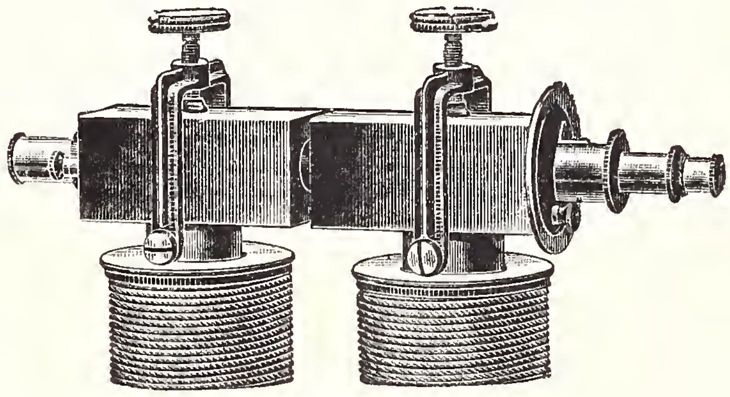


Fig. 39.
Arrangement for rotation of plane of polarization.

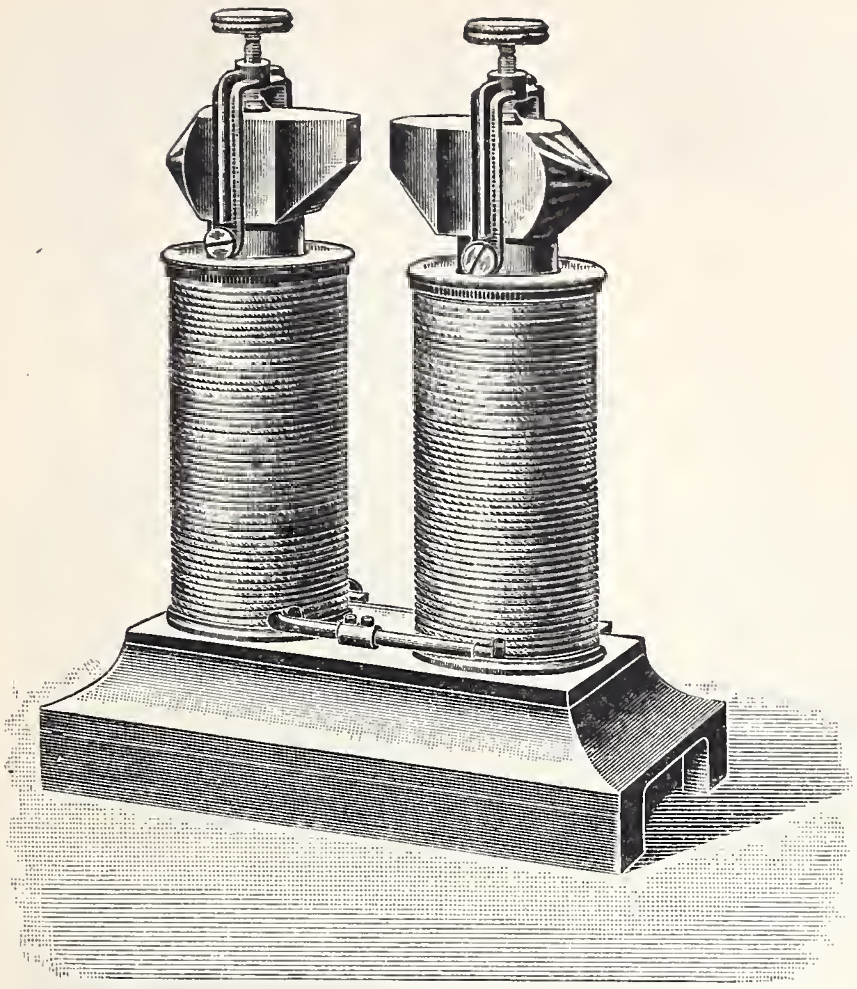


Fig. 40.
Arrangement for diamagnetic experiments.

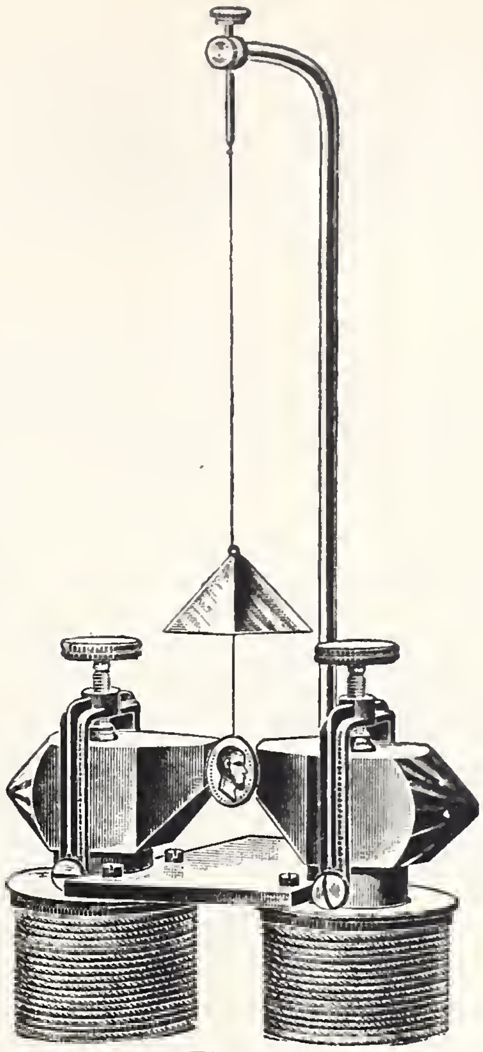


Fig. 41.
Arrangement for Tyndall's rotating coin experiment.

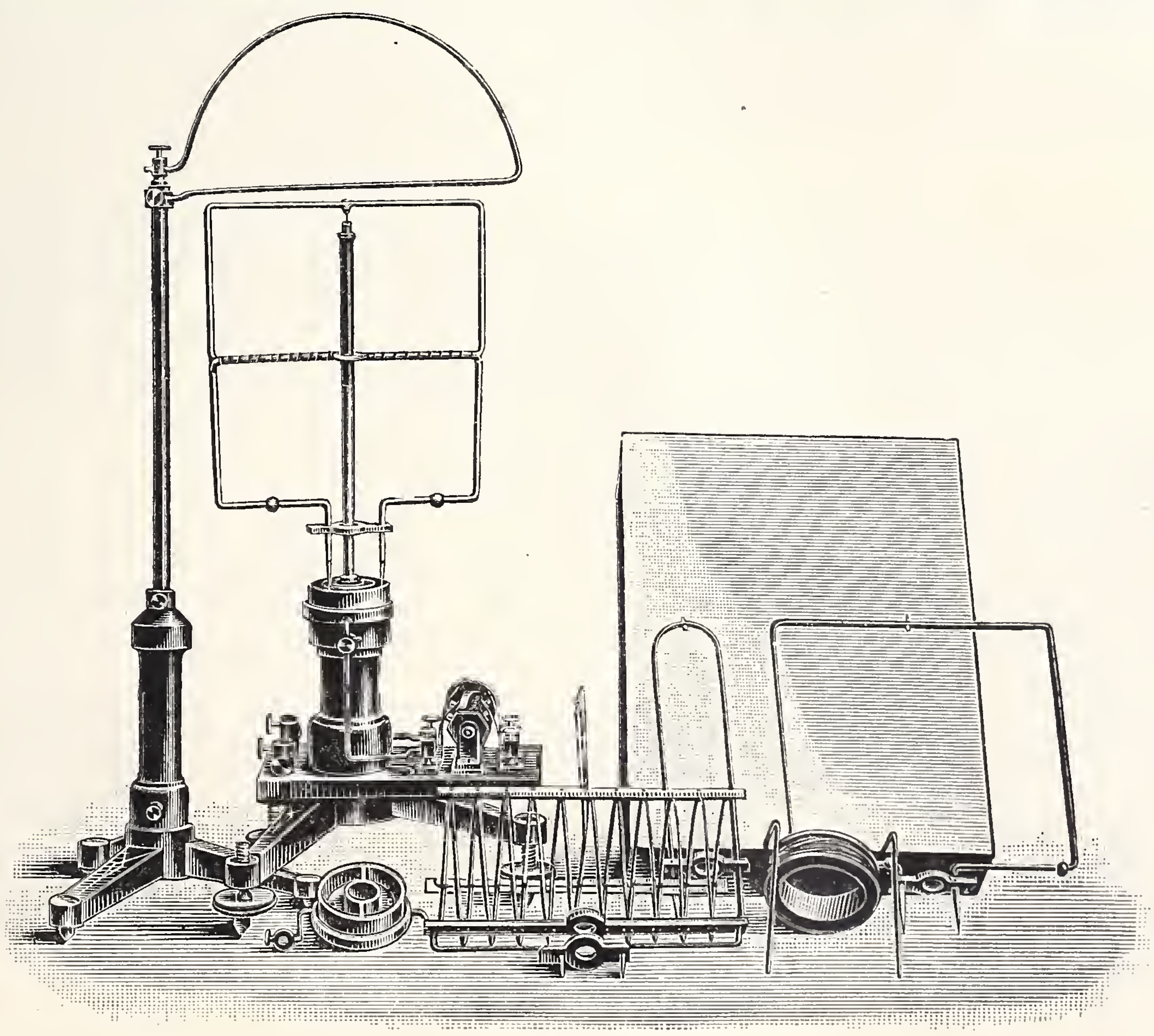


Fig. 42.

33. Ampère's Stand. Fig. 42. This is a new arrangement of Ampère's stand, which considerably enhances the success of the experiment. The main stand can be made to turn on the tripod and is adjustable by levelling screws. The wire figures are made of aluminium and tipped with silver; the figures include a simple quadrangle, a double astatic square, a wire arch, a solenoid, a coil of wire, a mercury cup with two concentric rings and a partitional mercury cup.

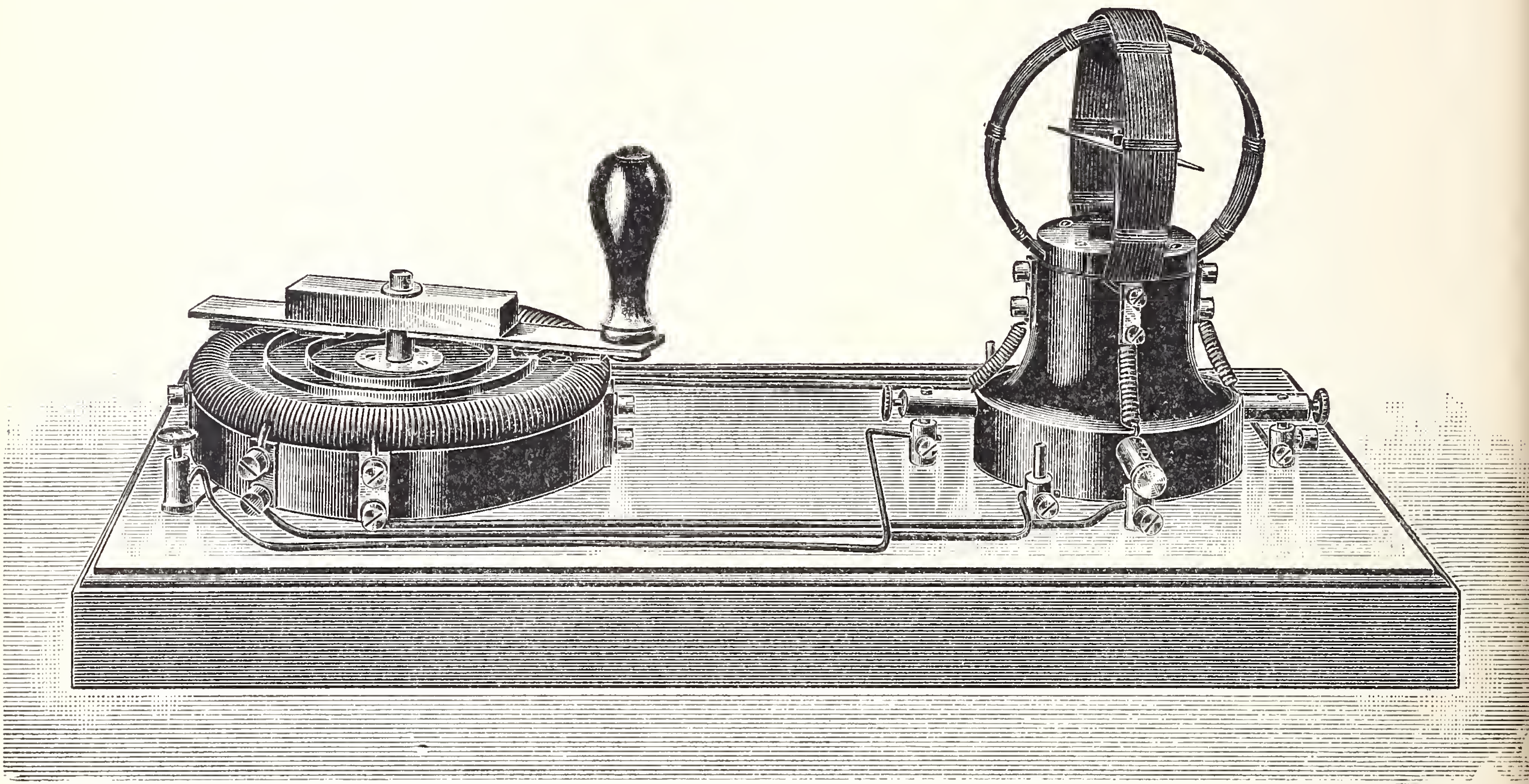


Fig. 43.
Rotatory field apparatus. Ferraris's coil for two-phase currents.

34. Weinhold's Apparatus for Demonstrating Two and Three-phase Currents. Figs. 43 to 46. This apparatus is beautifully adapted for all experiments with two and three-phase currents. The current is supplied by a few accumulators or Bunsen cells and transformed into two-phase or three-phase alternating currents. This current is passed through a Ferraris coil or Tesla rings and there imparts a synchronic rotatory movement to magnet needles and iron disks, or asynchronic rotation to an iron ring wound with copper wire. The lines of force of the rotatory field may also be demonstrated with the aid of a glass disk upon which iron filings have been sprinkled.

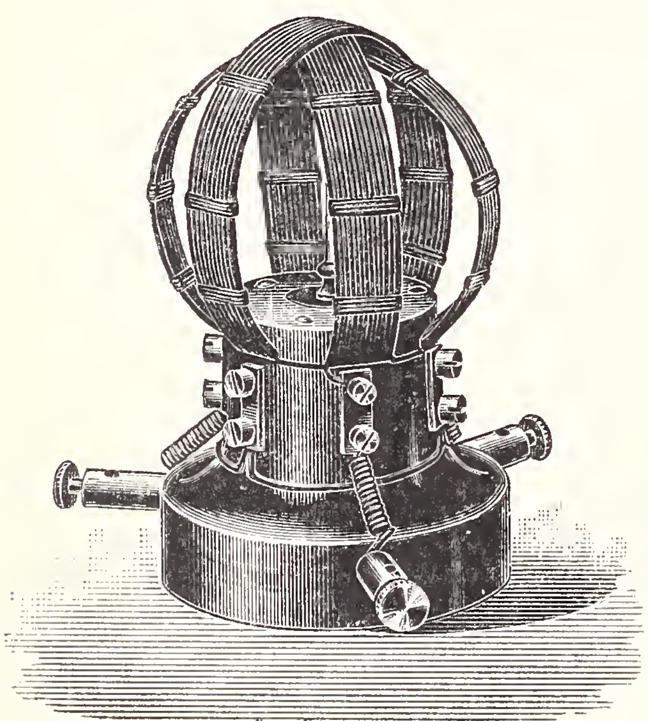


Fig. 44.
Ferraris three-phase coil.

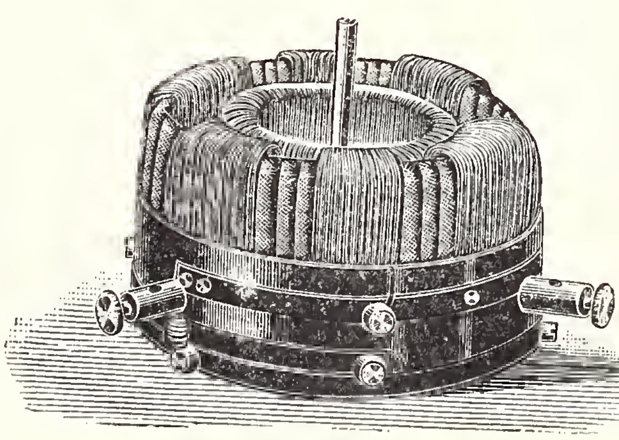


Fig. 45.
Tesla three-phase ring.

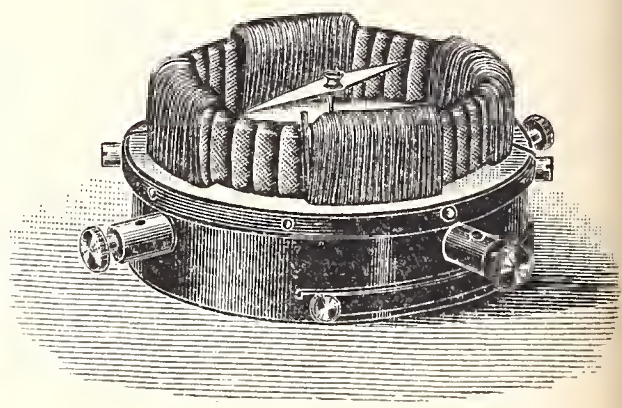


Fig. 46.
Tesla ring for two-phase current.

35. Model of an Asynchronic Three-phase Motor. Fig. 47.

36. Model of a Siemens Drum Armature. Fig. 48. This model demonstrates the mode of winding the armature. The latter is made to rotate by the passage of a current.

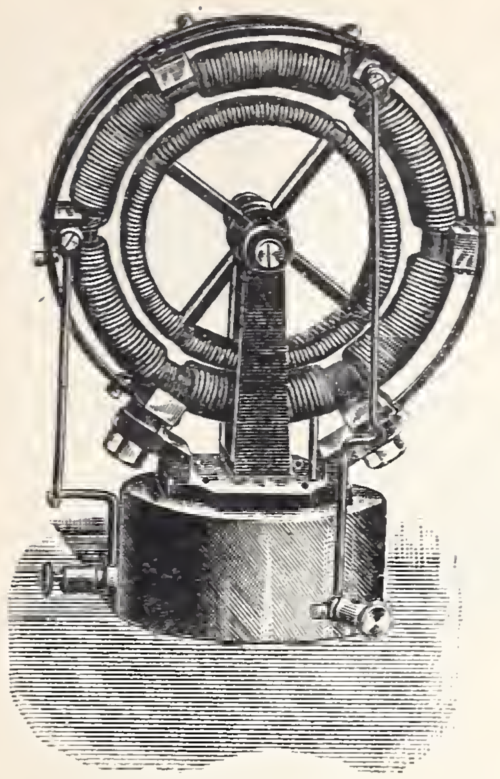


Fig. 47.

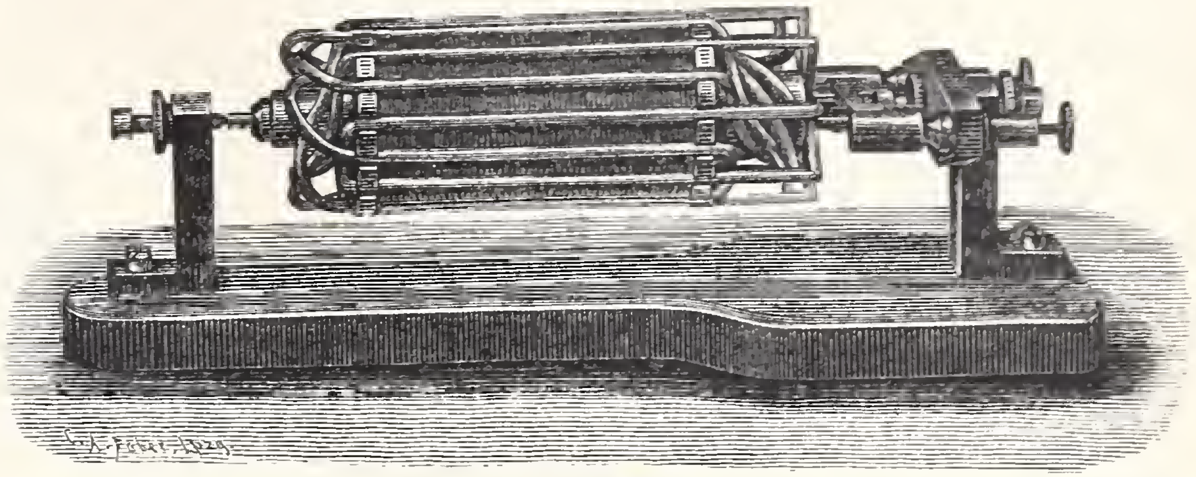


Fig. 48.

37. Secondary Battery for college use. Figs. 49 and 50. This battery is fitted with a switch, by means of which the cells can be coupled up in multiple arc, in groups and in series. A battery of six cells supplies at the user's option a current of 2 volts and 24 ampères, or 4 volts and 12 ampères, or 6 volts and 8 ampères, or 12 volts and 4 ampères. The cells are contained in a polished box, the back of which can be opened so as to inspect the cells. The battery is charged either from a continuous current plant with the interposition of a lamp resistance or by three Bunsen cells.

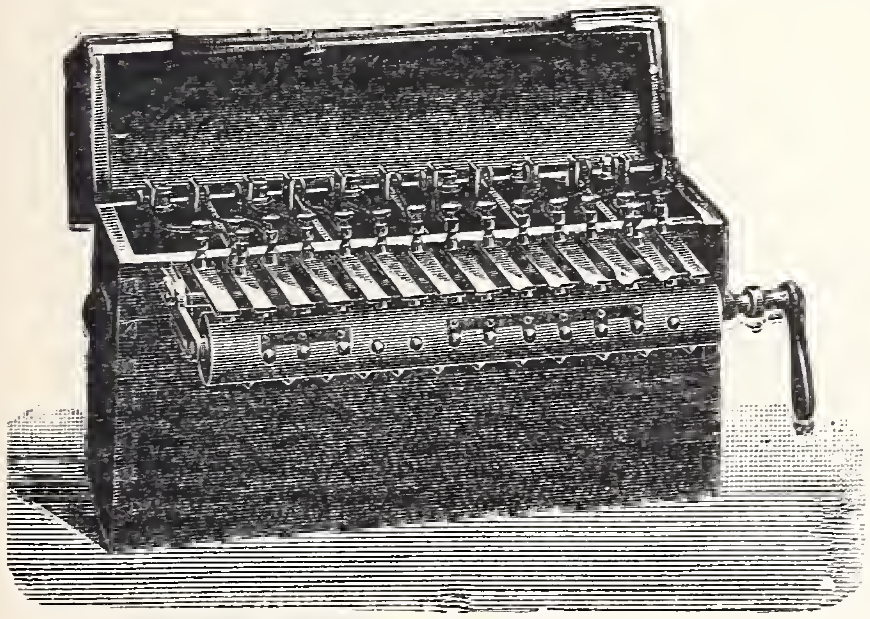


Fig. 49.
Front view.

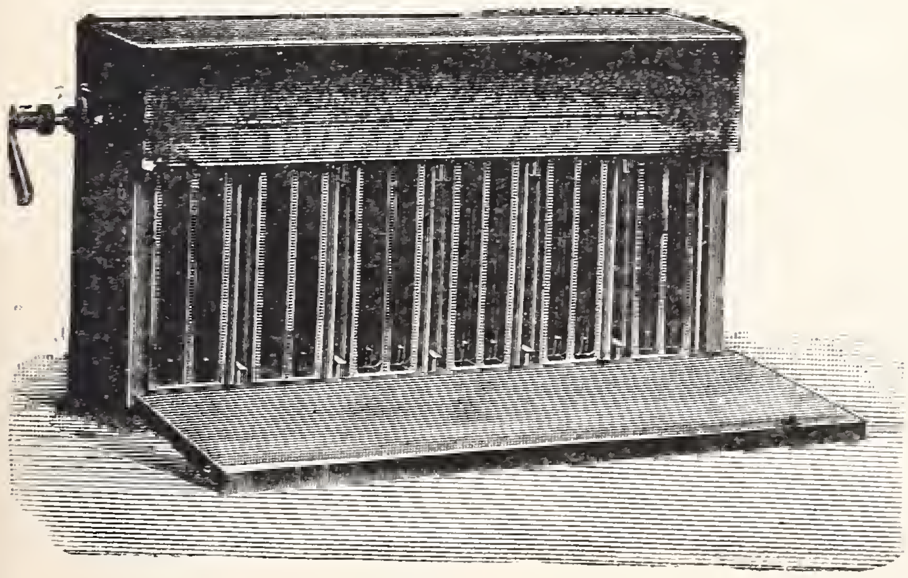


Fig. 50.
Back view (opened).

Fig. 51.

38. Selenium Cell. Fig. 51. This cell demonstrates in a beautiful manner the diminishing influence of light upon the resistance of selenium. When three dry cells, the selenium cell and a sensitive electric bell are joined in a circuit, the bell sounds whenever the cover of the selenium cell is opened so as to expose the latter to the action of the sun's rays, but it ceases ringing as soon as the lid is closed.

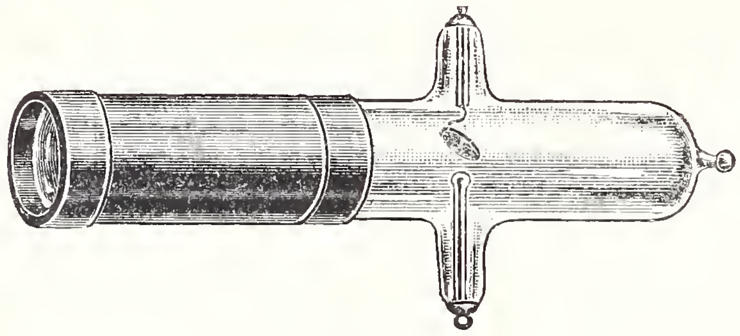


Fig. 52.

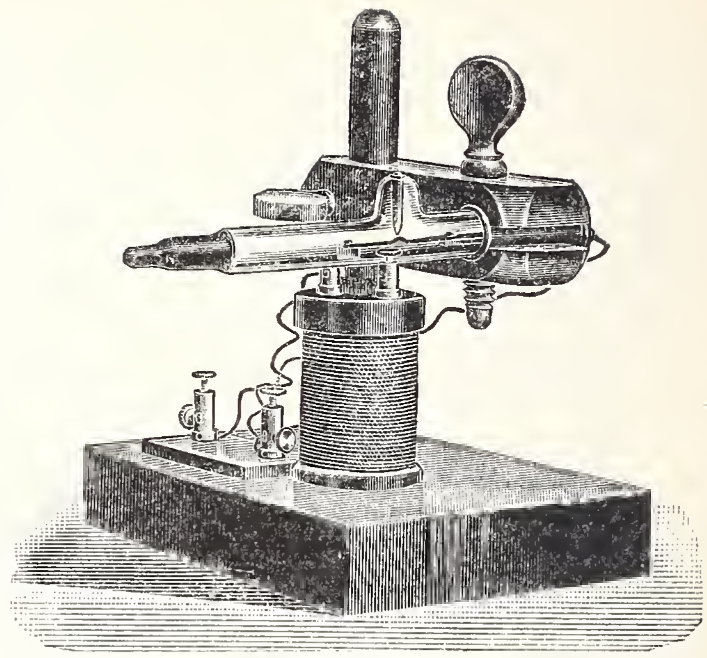


Fig. 53.

39. Zickler's Tube for Photo-electric Telegraphy. Fig. 52. Zickler's photo-electric method of telegraphy is based upon the fact that in a spark gap the spark passes in the presence of ultra-violet radiation and ceases upon its removal. The spark gap is enclosed in an exhausted glass tube having a

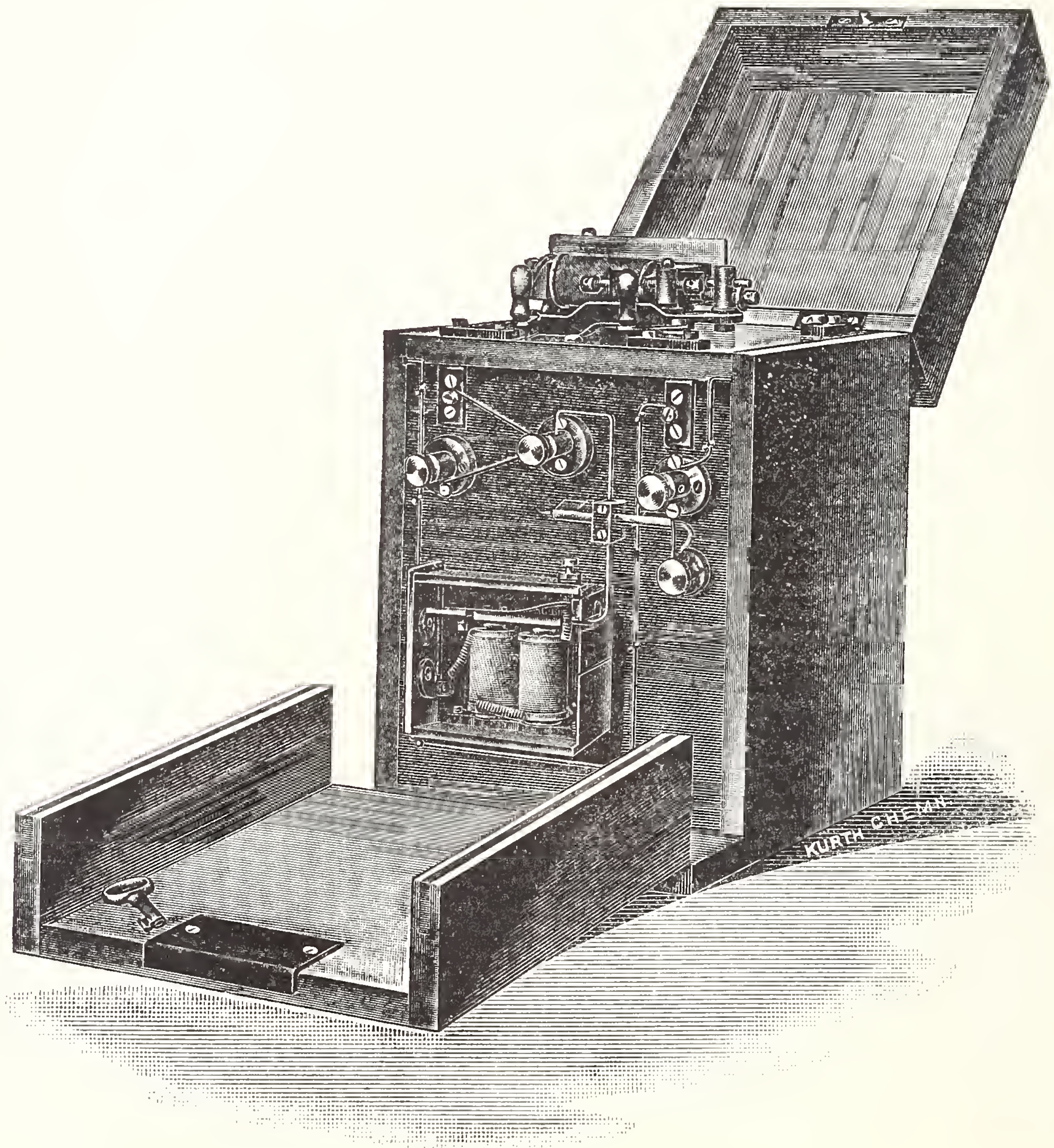


Fig. 54.

quartz window at one end. A movable quartz lens is fitted in front of this window so as to collect the ultra-violet rays on the cathode.

40. MacFarlan Moore's Vacuum Vibrator. Fig. 53. This is a platinum vibrator enclosed in an exhausted glass tube. The vibrator is set in motion by an electromagnet. Currents of a very high potential are induced within the electromagnet, by reason of the interruptions and the self-induction of the coil, the potential being sufficiently intense to render vacuum tubes incandescent.

41. Apparatus for Demonstrating Marconi's Wireless Telegraphy. Fig. 54. The transmitter consists of a Righi radiator, the receiver of a sensitive coherer, a battery of four dry cells, a polarized relais and a knocker. Both the transmitter and receiver are contained in a portable case which can be opened at the top and at the sides so as to render the apparatus accessible.

3. A. Krüss (Proprietor Dr. Hugo Krüss), Hamburg,

7 Adolphsbrücke.

Established 1796.

Optical Institute: Spectrum Apparatus, Prisms, Photometers, Projection Apparatus, Sciopticons, Lantern Slides.

(See also Sections Va, Vb and Vd.)

1. Colorimeter after C. H. Wolff. Fig. 1.
2. Colorimeter with Lummer and Brodhun's prism. Fig. 2.
3. Polarization Colorimeter with Grosse's prisms. Fig. 3.

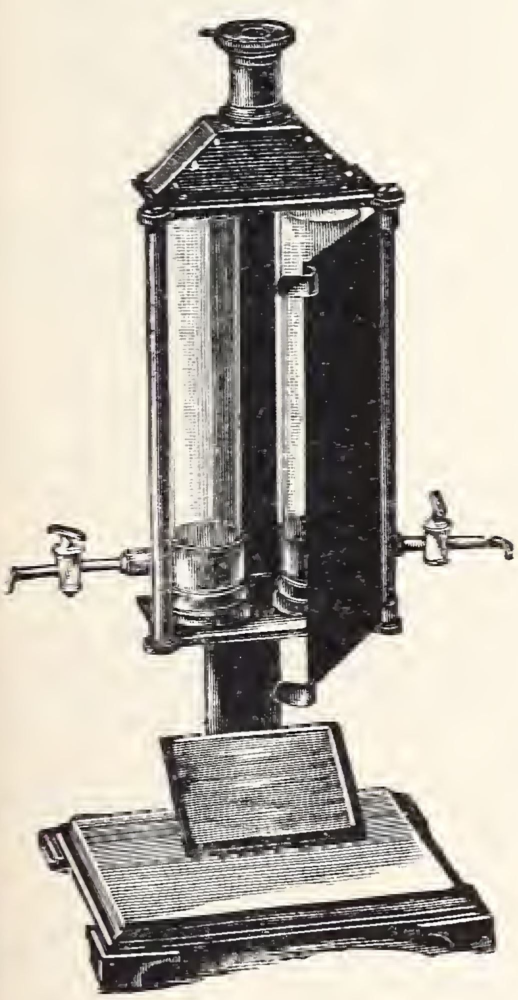


Fig. 1.

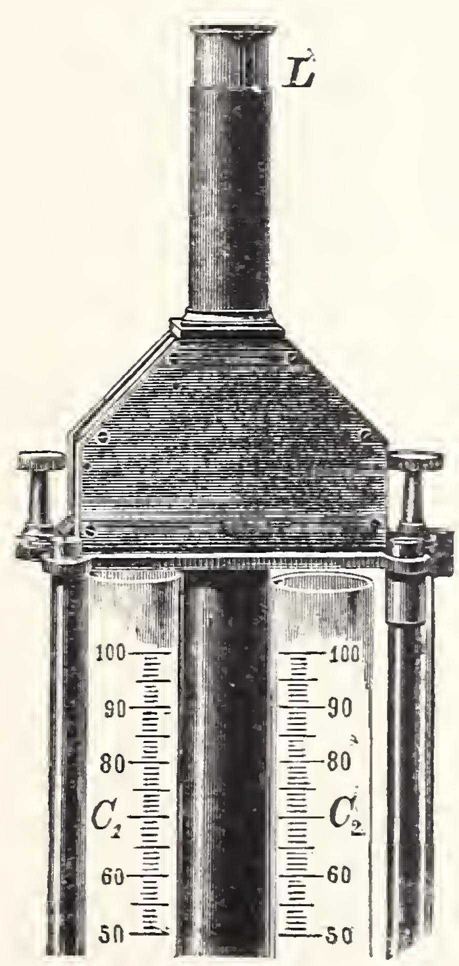


Fig. 2.

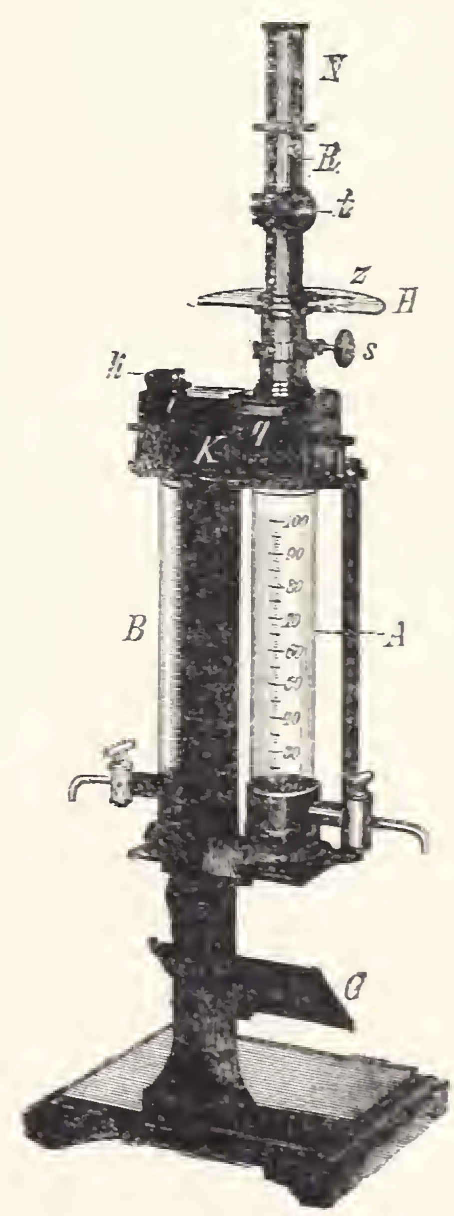


Fig. 3.

4. Richard Müller-Uri, Brunswick,

19 Schleinitzstr.

Maker of Physical and Chemical Lecture Apparatus. Instruments and Appliances for Scientific and Technical Laboratories.

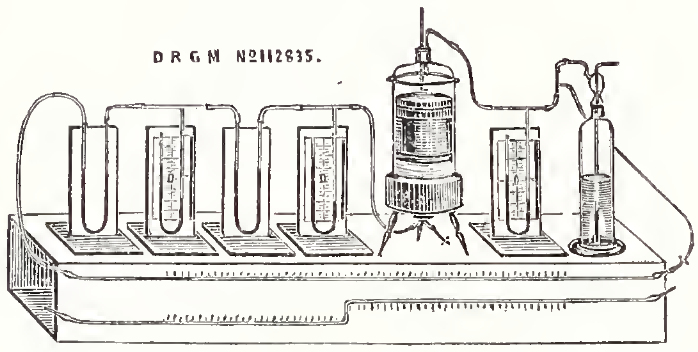


Fig. 1.

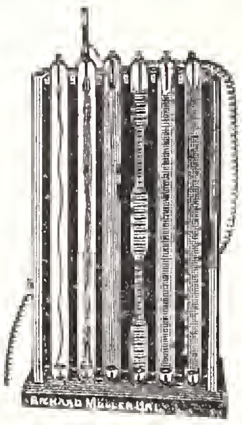


Fig. 2.

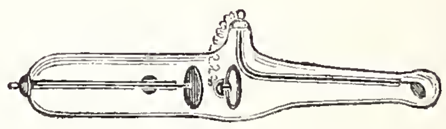


Fig. 3.

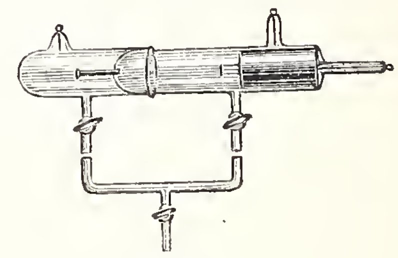


Fig. 4.

1. **Prof. M. Möller and B. Schmidt's Apparatus for Illustrating Electrical by Air Currents.** Reg. in Germ. No. 112,835. Zeitschrift für den physikalischen und chemischen Unterricht 1899. No. 5.—Programme of the Royal Gymnasium at Wurzen, Easter 1899. The object of this apparatus is to illustrate by concrete means the laws subsisting between the phenomena of the strength of a current, resistance and electromotive force. The apparatus is a rapid and complete aid in the formulation of clear fundamental notions, and thereby facilitates the advance, within a limited period, to the deeper and more complicated chapters of the subject. Fig. 1.

2. **Charles R. Cross's Vacuum Scale,** on special stand, as described in the Zeitschrift für den physikalischen und chemischen Unterricht Vol. 12. No. 4, being a series of six tubes giving a clear notion of the progressive rarefaction of air as observed in the tube connected with the air-pump. The following phases of rarefaction are demonstrated by their characteristic phenomena, viz.: 1. 40 mm pressure by a luminous thread (de la Rive); 2. 10 mm pressure by its dissolution; 3. 6 mm pressure by the production of a Geissler vacuum; 4. 3 mm pressure by stratification; 5. 0.14 mm pressure by the production of a Tesla vacuum; 6. 0.03 mm pressure by the production of a Crookes or Röntgen vacuum. The stand is adapted for demonstrating the tubes both conjointly and consecutively. Fig. 2.

3. **Röntgen Tube with Laterally Distanced Auxiliary Anode** (Reflector). Reg. in Germ. No. 115,474. Being a combination of a cylinder and cone it can be brought much nearer to the object than the other tubes now in general use. The tube can be used with weak currents only. It gives excellent results with a current of 1 ampère and 10 to 16 volts (as obtained with an induction coil of 10 cm sparking distance). Fig. 3.

4. **Lenard Tube for Observing the Effect of Cathode Rays,** with ground-on vacuum chamber, ready for evacuation. Annalen der Physik und Chemie N. F. 1894. The fore-chamber admits of observation both in vacuo and in spaces filled with any gas. This tube is also made with a ground-in cathode so as to admit of the interchange of variously formed electrodes. Fig. 4.

5. **Tesla Transformer without Oil-isolation,** modified after Elster and Geitel. This construction obviates the inconveniences attending the immersion of the appliances in oil, whilst in action it is considerably more powerful. By its simple, solid and accessible form it is a valuable and interesting educational instrument. A series of beautiful vacuum appliances has been specially constructed for this instrument. Figs. 5 and 6.

6. **Rud. Franke's Vacuum Transformer,** for alternating currents of very high tension and small intensity. Alternating currents are transformed into continuous currents on the principle of Holtz's tubes with blown-in glass funnels. Fig. 7.

7. **Vacuum Vibrator and Luminous Tubes** after MacFarlan Moore. Elektrotechnische Zeitschrift 1896. The interrupter being transferred into the vacuum space the frequency of the interruptions is considerably increased and scarcely any power is required for keeping up the oscillation. There is

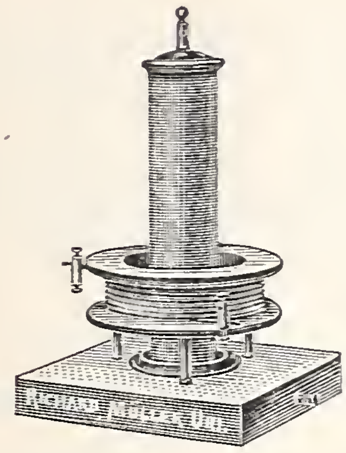


Fig. 5.

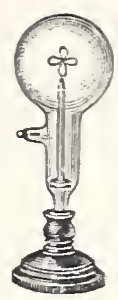


Fig. 6.

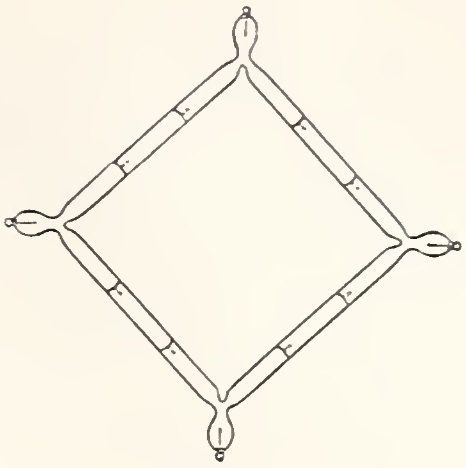


Fig. 7.

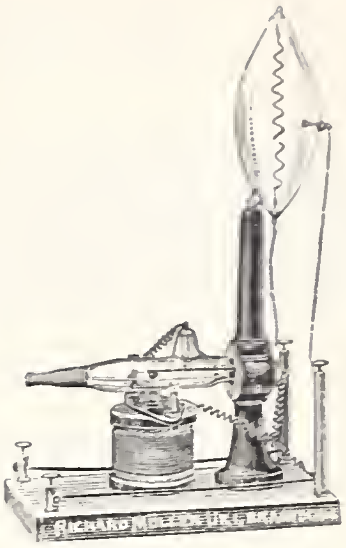


Fig. 8.

no secondary winding on the electro-magnetic bobbin. The light of the vacuum tubes requires only the 30th part of the energy necessitated by an incandescent lamp of similar luminosity. The whole of the connections are exposed to view. Fig. 8.

8. **Thomson's Vacuum Tube for Secondary Cathode Rays** in the shape of a double W. The tube is of great interest for the study of the phenomena of discharges in high vacuum tubes.

Fig. 9.

Fig. 10.

Fig. 11.

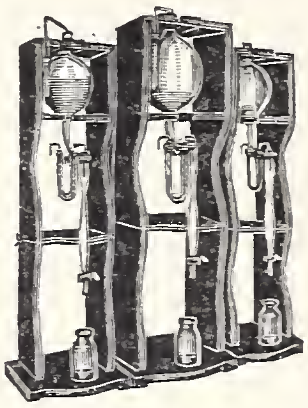


Fig. 12.

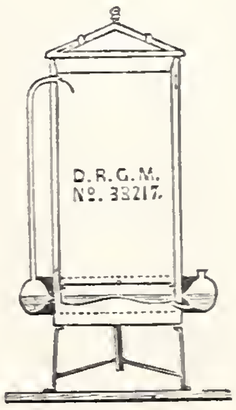


Fig. 13.

9. **Elster and Geitel's Dry Pile** with intensifying screw, suspension stand and pole-needle for shortening the column. If carefully treated the pile will endure for an unlimited period. It should be kept suspended in a dry room. It displays of all piles with copper and zinc elements the highest voltage (up to 450 volts). Fig. 9.

10. **Dolezalek and Nernst's Dry Pile.** Zeitschrift für Elektrochemie III. 1. The copper and zinc elements are here replaced by a combination with a powerful depolarizer (electrolytic peroxide of lead and tin). Its power is extraordinarily high, tensions of many hundred volts being obtainable with piles of small thickness. Fig. 10.

11. **Boltwood's Mercurial Air-pump** with automatic mercury elevator, preliminary suction, vacuum gauge and stand. The best of modern circulating pumps. Fig. 11.

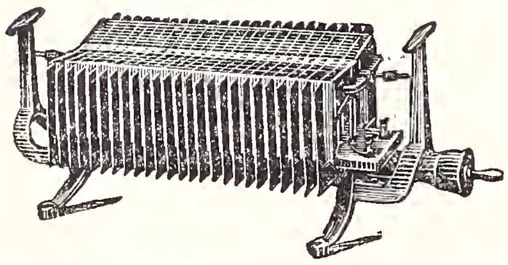
12. **Branly and Marconi Coherers.**

13. **Serial Filling Pipettes** after Prof. Dr. Hugo Schultze, for accurately and quickly measuring off solutions in continued series of analyses of one kind. This form has proved eminently useful in large laboratories. The apparatus has two fine glass-cocks, a reservoir of 1 to 2 litres capacity and two U-tubes for drying the inflowing air. Fig. 12.

14. **Rapid Sterilizer for Bandages,** with double jacket and concentric double storing water vessel. Reg. in Germ. No. 38,217. The steam current is maintained at 100° C. in all regions of the internal chamber (50×20 cm and 60×25 cm respectively) by the rising heating gases in the double casing. The consumption of water being very small, the apparatus is available for continued use. Fig. 13.

15. **Set of Prof. Dr. Reinke's Thermometers and Areometers** and appliances for agricultural chemistry and fermentation laboratories.

5. Julius Pintsch, Berlin O., 72/73 Andreasstr.



Gülcher's Thermo-electric Piles heated by gas. Particularly adapted as current generators for working induction coils in connection with Röntgen experiments, &c.

They are excellent substitutes for galvanic cells, since they possess the following advantageous features:—The E. M. F. is constant; little gas is consumed, while the efficiency is very high; there are no fumes or smell, and interruptions in working do not occur.

Agents for France: Messrs. S. Grauer & Co., 74/76 Boulevard Richard Lenoir, Paris.
- - Belgium: Messrs. S. Grauer & Co., 2/4 rue de la Roue, Brussels.
- - England: Messrs. O. Berend & Co. Ltd., Dunedin House, Basinghall Avenue, London, E.C.

6. Fr. Schmidt & Haensch, Berlin S., 4 Stallschreiberstr.

Optical Works.

(See also Sections Va, Vb and Vd.)

The colorimeters, like all other photometric appliances, include two essentially different parts, viz. an element for comparison and a measuring or moderating device. In the colorimeters the comparison element consists generally of two Fresnel parallelepipeds and a lens having the line separating the comparison field in its focal plane. In the measuring device the same fundamental idea underlies the construction of all colorimeters inasmuch as the two comparison fields are illuminated through the substance of two absorbing strata, the depth of one of which can be varied until both fields appear to be equally bright and similarly tinted.

The delicacy of the adjustment is considerably enhanced if only such light is allowed to reach the comparison fields which is powerfully absorbed by the fluid experimented upon. This requirement is realized by combining the colorimeter with an apparatus for spectroscopically decomposing the light.

The exhibits include:—

1. **Martens'[1] Colorimeter** with Lummer and Brodhun's cube adapted for use in conjunction with spectroscopes fitted with a wave-length scale.

2. **Colorimeter** with twin comparison prism for use in conjunction with spectroscopes fitted with micrometers for measuring wave-lengths.

3. **Martens' New Colorimeter.** The comparison element consists of a twin prism (see Section Va, No. 5a) and has over the usual appliances consisting of two Fresnel prisms the great advantage of causing the separating line between the two fields to disappear altogether, which materially enhances the rapidity and delicacy of the adjustment. The experimenter looks through the comparison apparatus in a horizontal direction. The measurements are made by raising or lowering a vessel containing the liquid under examination with respect to a stationary immersion tube by means of a rack and pinion movement. A millimetre scale shows the thickness of the stratum. The vessels may be surrounded by a warming arrangement. Selectively absorbing glass plates or Landolt's light-filters may be slid into the focussing lens in order that only such rays may reach the eye which are largely absorbed by the fluid. Solutions are best compared with a solution of a known degree of concentration of the same substance having a constant depth.

4. **New Spectrum Colorimeter,** differing from No. 3 only in that the light is decomposed spectroscopically. The telescope can be turned by a micrometer screw round a horizontal axis for the purpose of adjusting and measuring the wave-length of the approximately homogeneous light proceeding from the comparison fields.

5. **New Colorimeter** fitted with Lummer and Brodhun's cube, otherwise similar to No. 3.

6. **Stammer's Colorimeter** fitted with Fresnel's comparison prisms and vertical lens. The greatest depth of fluid is 350 mm. This colorimeter is principally used in conjunction with standard glasses for the examination of petroleum.

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[1] Scientific optician of the firm.

IX. Drawing and Calculating Appliances.

1. Arth. Burkhardt, Civil Engineer.

Glashütte, Saxony.

Post and Telegraph Office, and Station on the Müglitzthal Railway.

First German Calculating Machine Factory. Maker of Instruments of Precision.

Established 1878.

Calculating Machine embodying the latest improvements, for Addition, Subtraction, Multiplication, Division, Powers and Roots. The machines, of which over 1,000 are in actual use, have repeatedly been awarded national prizes, gold and silver medals at home and abroad.

The instrument is made in the most exact manner under careful supervision in three sizes:

1. Six	figures, factors of	6×7	figures and product of	12 figures
2. Eight	- -	8×9	- - - -	16 -
3. Ten	- -	10×10	- - - -	20 -

Repairs are scarcely ever needed. Splendid testimonials.

These machines can be forwarded by post and are supplied with a two years guarantee.

Price-lists may be had free on application.

2. Gustav Charitius, Weimar.

Mechanician and Optician.

1. **Planimetric Compasses No. 1.** These work absolutely uniformly and freely, and there is no play. The steel points are carefully hardened and are made slender so as to cast scarcely any shadow.

2. **Planimetric Compasses No. 6** fitted with adjustable stop for certain positions of the points.

3. **Planimetric Compasses No. 15.** Similar to No. 6, fitted with stop corresponding to 100 mm between the points, and with counting wheel indicating how many times 100 mm have been measured off.

4. **Pantograph No. 3.** The pole of the instrument is placed upon a pin projecting from the accompanying steel vice, which is clamped to the table. The arms are adjusted with the aid of the divisions marked upon them. For reductions the drawing pin is placed between the pole and the tracing pin, and amplifications are obtained by interchanging the drawing and tracing pins. The tracing pin is clamped by a lateral pin, whereas the drawing pin fits loosely in a sleeve so as to draw by its own weight. For merely dividing off, the lead should be replaced by a needle. The latter should be screwed in so as to place its point a short distance above the paper, and the punctures are made by depressing the large brass button above. For this purpose the milled spring casing should be screwed upwards as far as necessary.

The numbers appended to the above instruments refer to the firm's catalogue.

3. A. W. Faber, Stein near Nuremberg.

1. **Boxwood Slide-rules with Glass Slide.** Fig. 1. This slide-rule solves with the greatest ease any of the following problems:—the ordinary arithmetical operations, multiplication and division, calculation of ratios within three places of decimals, calculation of interest, areas, volumes and

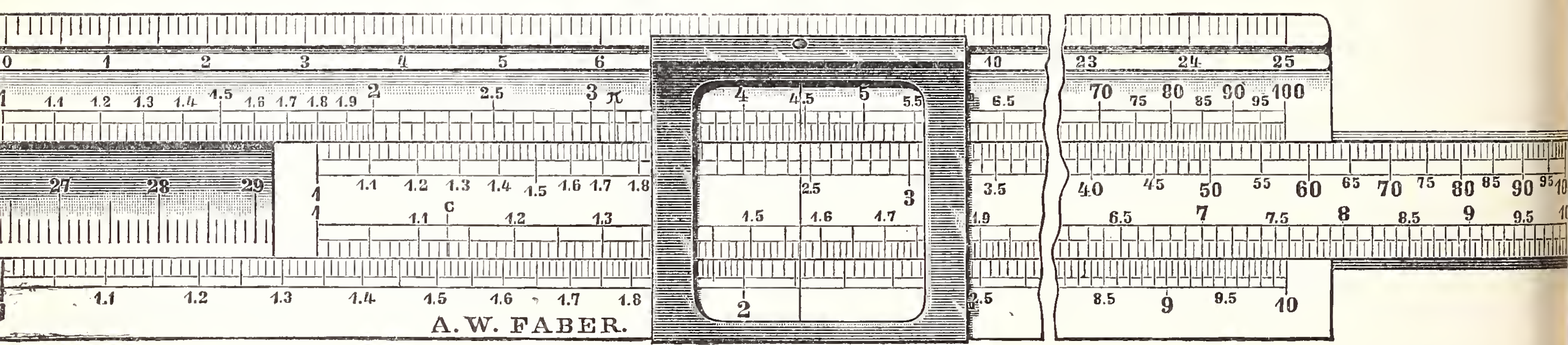


Fig. 1.

weights. It is also adapted for technical calculations, trigonometry and logarithmic work.

This slide-rule, which bears the German patent No. 98,350, is fitted with a lateral spring ledge which presses evenly upon the slide, thereby preventing it from working too loosely or too lightly, so as to facilitate the adjustment.

2. **Drawing Rules.** Any of the rules are divided, to order, according to the metric, English or Russian systems. The metric scales are divided into $^1/_1$ or $^1/_2$ mm, English inches into $^1/_{32}$, the Russian into sagènes and archines. These scales are made of sycamore or boxwood, with or without brass ledges, with metal knob or round wood handle and comparison scale.

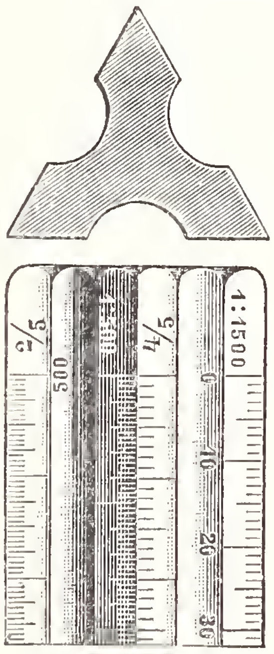


Fig. 2.

3. **Scales.** Fig. 2. These are made of unstained polished boxwood, they are triangular in section and bear six ratios, viz. 1:1,000, 1:2,000, 1:2,500, 1:500, 1:1,250, 1:1,500; also 1:5, 1:10, 1:15, 1:20, 1:25, 1:30, 1:33$^1/_3$, 1:40, 1:50, 1:75.

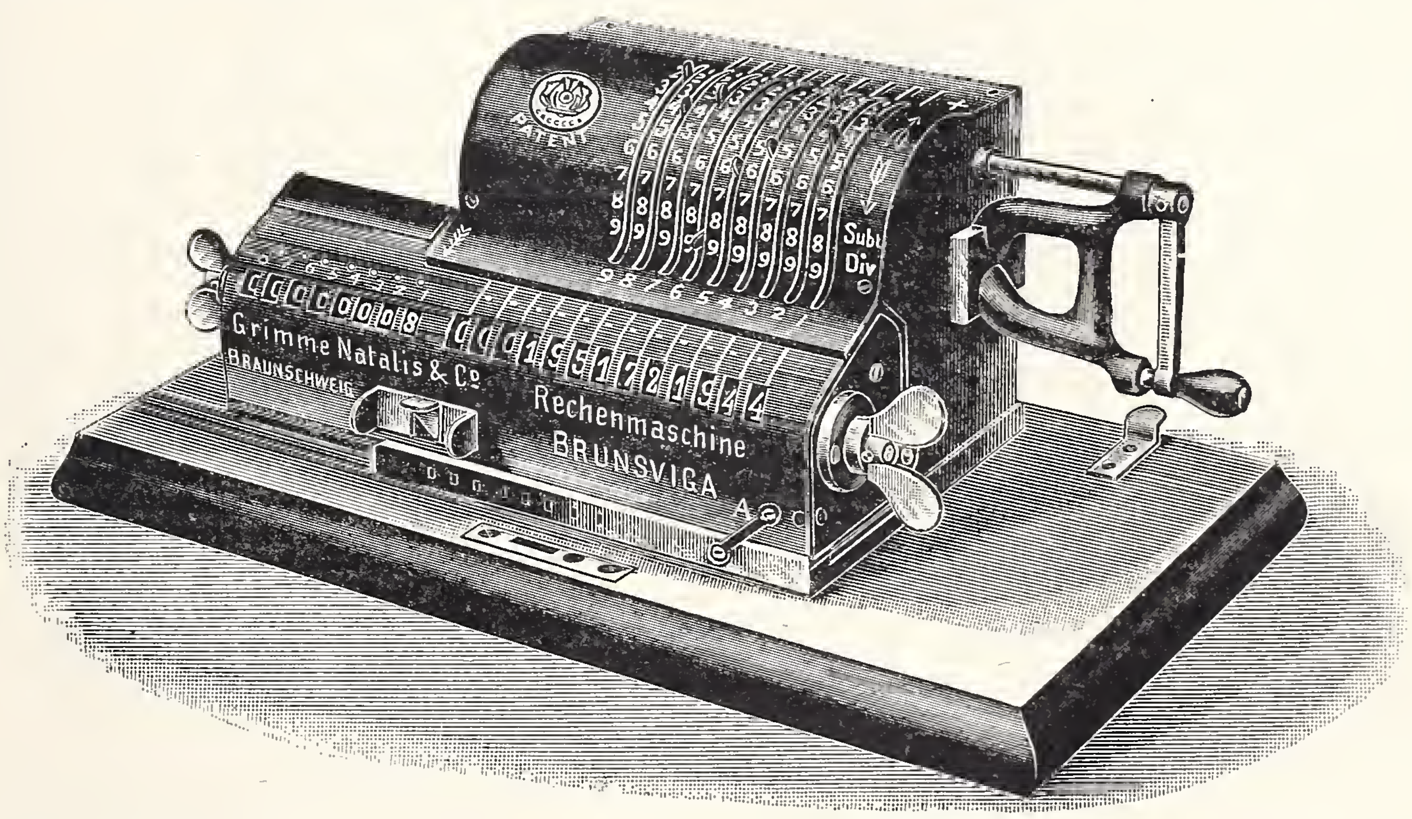
4. Grimme, Natalis & Co., Brunswick.

Syndicate. Established 1864.

1. The Brunsviga Calculating Machine. W. Th. Odhner's patent automatic calculating machine, known as the "Brunsviga Calculating Machine," has been awarded prizes on several occasions, e. g. at the international exhibitions held at Antwerp, Brussels, Chicago. It is adapted for all fundamental operations and their combinations (e. g. calculation of interest, powers, roots, series, equations, &c.). It serves as an auxiliary for general daily use in lieu of the fatiguing process of mental calculation.

Its use does not involve the necessity of long preliminary practice. A few minutes suffice to familiarize anyone with its use.

After setting the given numbers entering into the calculation upon the cover with the aid of the small projecting levers, further operations consist exclusively in turning the crank and sliding the lower number-box in certain cases. The figures are always in sight and the apparatus notes automatically the number of crank movements. It is therefore almost impossible to commit an error; should this nevertheless occur it is only necessary to turn the crank back to the point where the mistake occurred, but there is no need to retrace the entire calculation.



This handy apparatus is small enough for being placed on any ordinary table. Its mechanism is very simple, all its parts are solidly constructed and scarcely subject to wear and tear; repairs are therefore rarely required, as experience has amply testified, many thousands of these instruments having been in use for years.

Machines A and B are fitted with a bell which signals the impracticability of any excessively large calculation.

The Brunsviga machine is made in three sizes:—

Size A, extra large (37 cm long) with bell, is available for unusual calculations; it has 9 places for the fundamental number, 10 places in the small and 18 places in the large number-box.

Size B, ordinary pattern with bell, 23 cm long, with 9 places for the fundamental number, 8 places in the small and 13 places in the large number-box.

Size C, small pattern without bell, available for all calculations occurring in the counting house and architect's office, 23 cm long, with 7 places for the fundamental number, 8 places in the small and 10 places in the large number-box.

2. Adding Machine. This machine works out mechanically the addition of numbers and long columns with extraordinary rapidity.

Adding Machine No. 1 is available for the addition of numbers of one to six figures and for totals up to eight figures, e. g. 999,999.99, Machine No. 2 is available for the addition of numbers of one to five figures and totals up to seven figures, e. g. 99,999.99.

The operation is accomplished by depressing keys, as in a typewriter, and by a crank-movement.

The number so marked appears at the front of the machine, thus showing that the correct key has been depressed, which is a great advantage possessed by this machine over others. Any error made previous to the rotation of the crank can be corrected. The totals appear on the machine above the key-board. Each item is printed on an automatically moved paper ribbon in a vertical column, so as to furnish a copy of the addition. The sum total is placed below this printed column.

The machine is particularly useful in those cases where it is required to extract for addition various items out of an entire column.

The use of the machine does not involve the necessity of continued practice, and the keys are depressed without effort.

5. Christian Hamann, Friedenau near Berlin, 17 Hedwigstr.

Philosophical Instrument Maker.

1. Curve Tracer for describing large circles.
2. A Set of frequently used Border Stamps for rapidly describing, in Indian ink, circles and squares round a given centre.
3. Tichy's Tacheometric Plotter fitted with disk guides in lieu of conical wheels. The centre does not require perforation. The circular graduations are read by means of a guide roller.
4. Tacheometric Plotter with needle in the centre and graduated wheel.
5. Contouring Scriber, for plotting contours. See Zeitschrift für Vermessungswesen 1898. p. 230.
6. Coordinate Planimeter. See Zeitschrift für Vermessungswesen 1898. p. 553.
7. Polar Planimeter for small areas.
8. Polar Planimeter with zero constant.
9. Prytz's Beam Planimeter with wheel and inking pad instead of a blade.
10. Momentum Planimeter on Jakob Amsler's principle, but modified in detail.
11. Calculating Machine with one interpolator only.

The whole of these instruments belong to the Geodetic Collection of the Royal Agricultural College of Berlin.

6. Clemens Riefler, Nesselwang and Munich (Bavaria).

Mathematical Instrument Works.

(See also Section II.)

Mathematical and Drawing Instruments for all technical purposes.

The most important drawing instruments, in addition to the drawing pens, are compasses with needles, pencil, ink and hair spring bows.

All these instruments are made on the cylindrical system introduced by this firm in 1877. The cylindrical form of body possesses so many advantages over the older and polygonal pattern with triangular points, that the latter is gradually disappearing, and now that the original patents have expired the majority of other firms have likewise adopted this system. The shanks of these in-

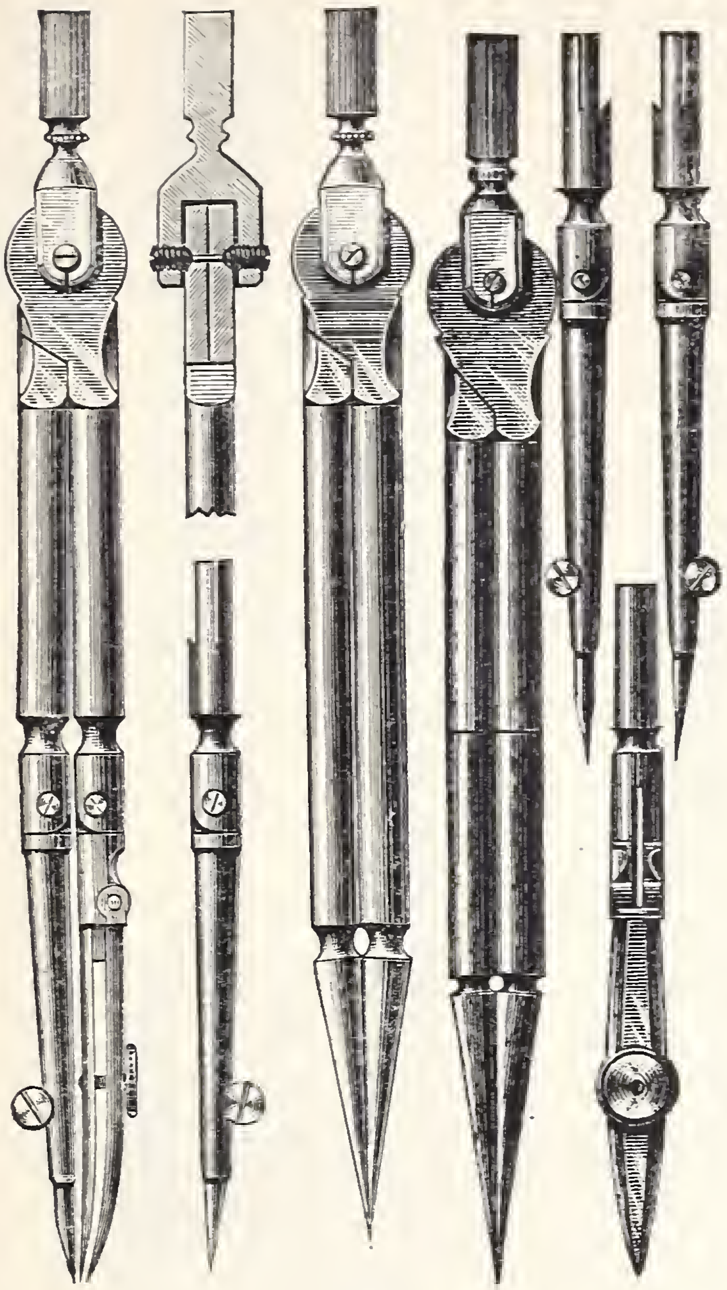


Fig. 1.

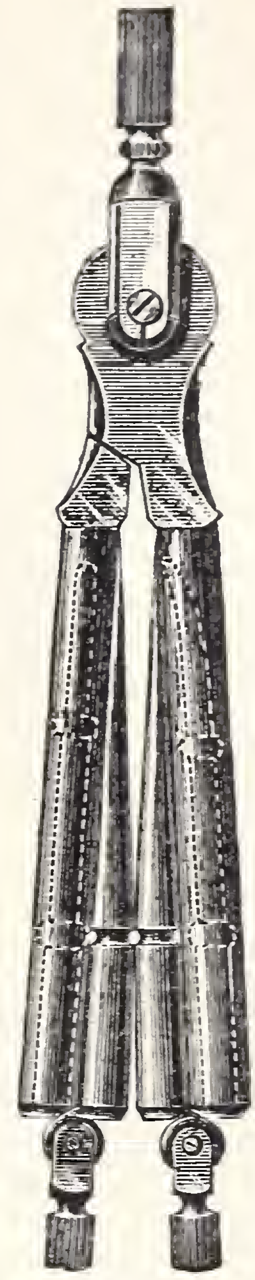


Fig. 2.

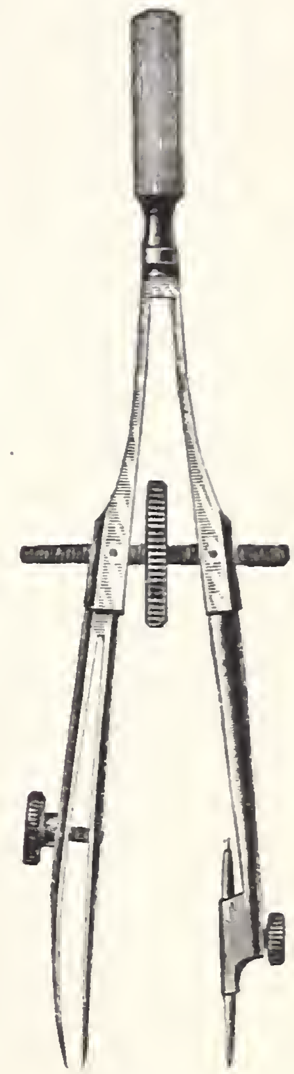


Fig. 3.

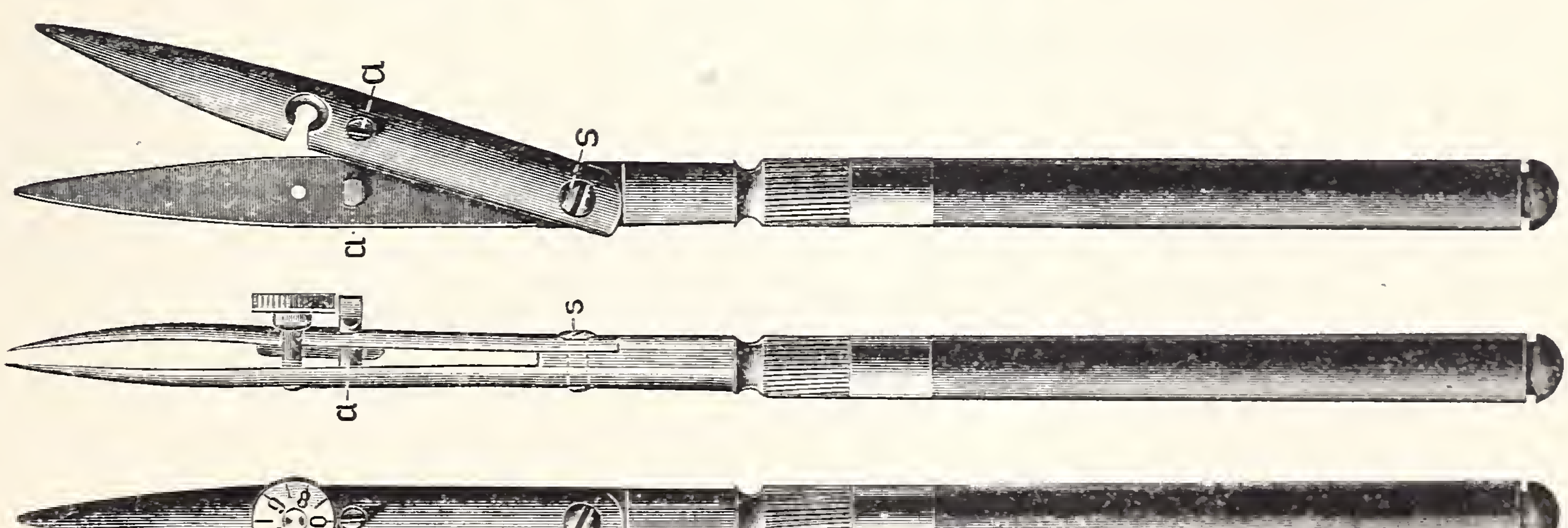


Fig. 4.

struments are cylindrical (Fig. 1), the steel points conical and attached by a screw, not merely soldered, so as to render them renewable. The ink and pencil bows have cylindrical pins tightly fitting the shanks so as to render clamping screws unnecessary. The joints move between screw-centres absolutely uniformly, without back lash.

The exhibits include a great variety of drawing pens, with and without turn-up nibs, double pens, curve pens, triple and bordering pens. In addition to these, attention is drawn to new drawing pens with micrometer set screw and lateral nib turning up without altering the setting of the breadth of the line (Fig. 4).

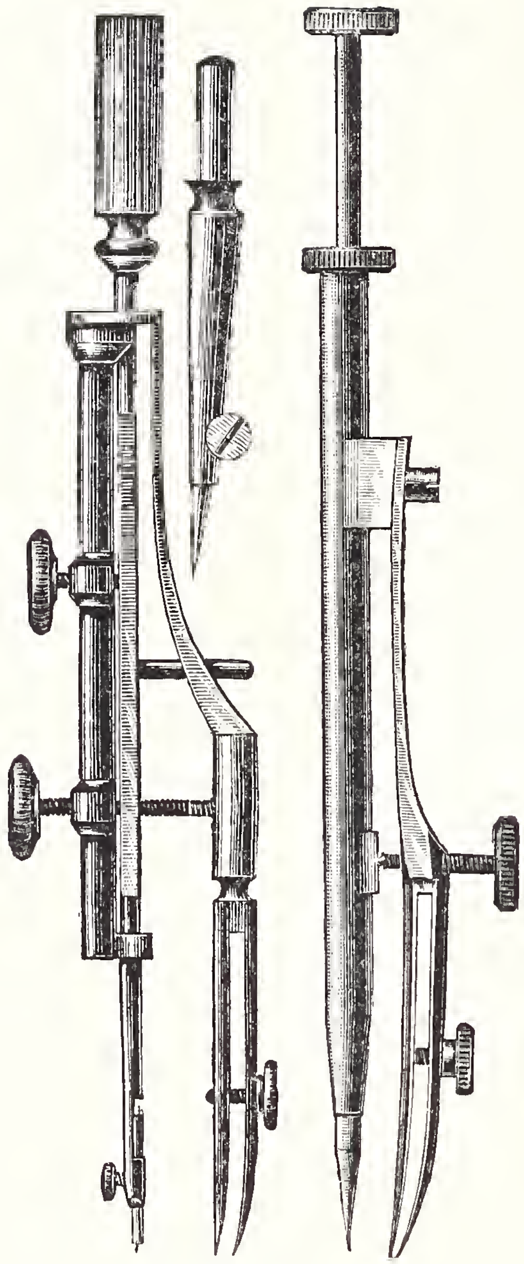


Fig. 5.

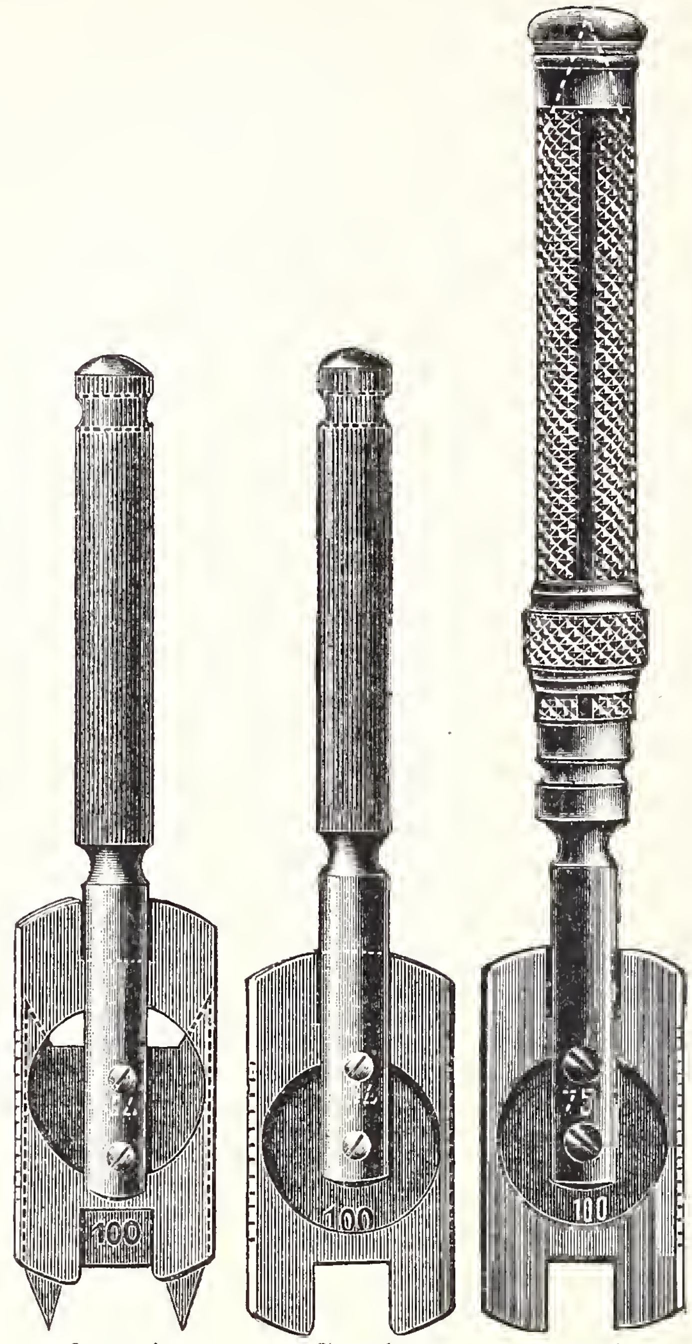


Fig. 6.

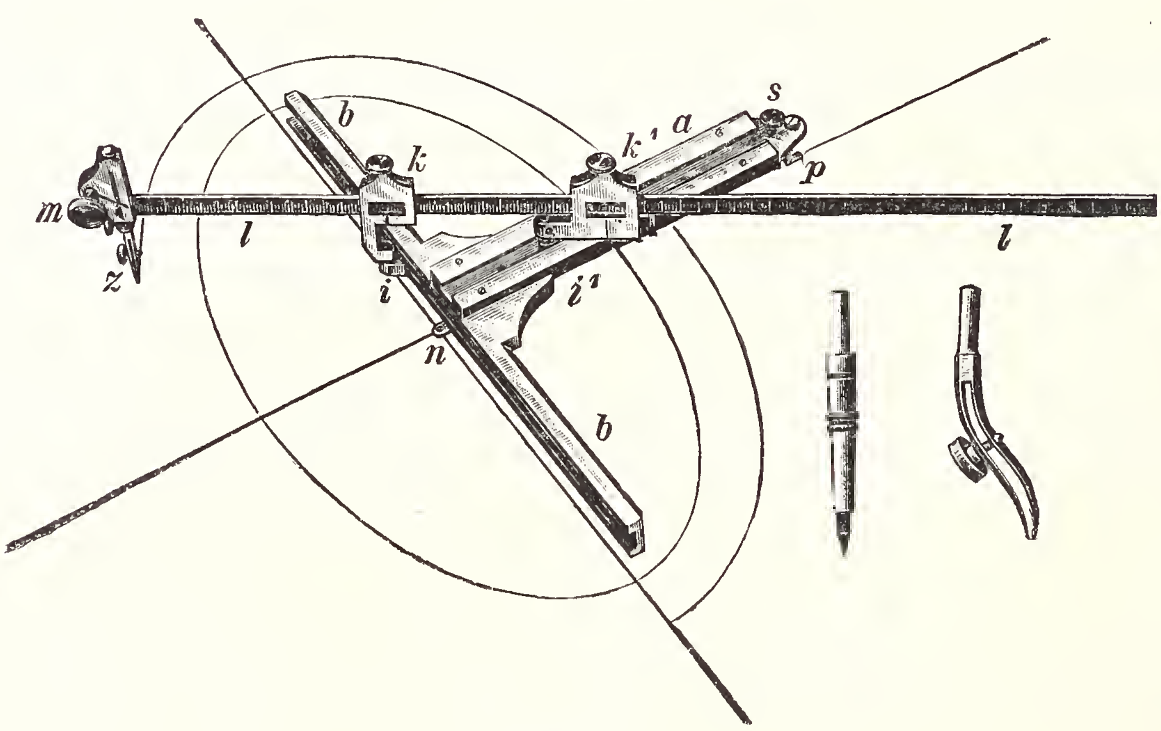


Fig. 7.

There are also pocket compasses with and without needle (Fig. 2), ink, pencil and pen bows (Fig. 3), and hair-spring bows (Fig. 5), proportional and beam-compasses, triple pointed compasses, map dividers (Fig. 6), for pricking off distances on maps and plans,

protractors with and without alhidada, scales with and without transversals, opisometers for measuring curves, dividers for trisecting angles, sectional ruling apparatus (Fig. 8), parallel rulers, slide rules, ellipsographs (Fig. 7) of various forms, and several other allied instruments.

As a contribution to the question of the decimal division of the circle, a protractor divided in this manner will be found among the exhibits, although it appears for several reasons to be advisable to retain the customary division of the circle into 360° and to divide each degree decimally into 100 minutes and each minute into 100 seconds.

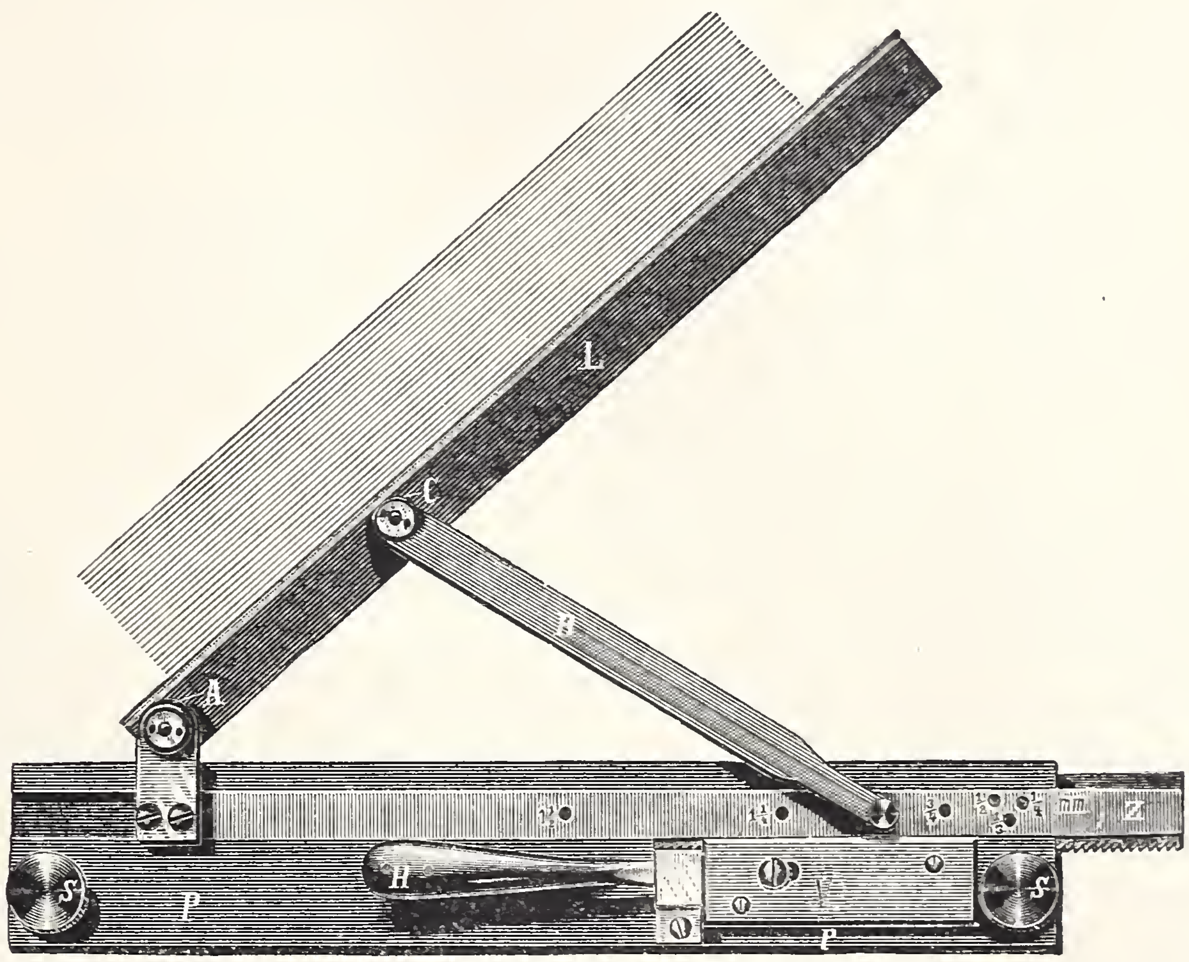


Fig. 8.

If, however, it be desired to establish complete agreement between the circle divided in angular measure and the hour circle (as set forth in the remarks respecting the exhibits comprised in Section II), it would be necessary to divide the circle into 24 degrees and each degree into 100 minutes and 100×100 seconds. The protractor referred to is intended to illustrate this mode of division. It possesses as an instrument for setting out angles certain practical advantages, since it admits of angles being drawn with ease and accurately within 1 minute or the $^1/_{2400}$ part of the circumference.

7. Gebr. Wichmann, Berlin N.W. 6, 13 Karlstr.

Various Zero Compasses and Dividers, the legs of the latter being made of one piece of steel.

Reducing Compasses having their points set off at right angles to facilitate the process of gauging and final adjustment.

Drawing Compasses of various sizes provided with ball-headed joint. The heads are fitted with stems, and are made of the toughest solid rolled German silver wire, but the points are made of the finest steel. The spherical head shows in any position of the legs a completely circular joint.

Beam Compasses. Each box is made of one piece of rolled German silver, and bending of the cheeks of the boxes by the pressure of the clamping screw is almost entirely obviated. The micrometer-screw is of a simple, improved form.

Drawing Pens for Straight and Curved Lines. Every pen is made of one piece of best steel, and fitted either with a transverse or pressure screw, or it is made adjustable by a movable wedge.

Cast metals are not used in the manufacture of any of these instruments.

8. Ad. Zwickert, Kiel, 25 Dänischestr.

Optician. Mechanician to the Royal Physiological Institute of Kiel.

Gold Medal and Diploma: Kiel 1896. Gold Medal: Brussels 1897.

[See also Section VII.]

Prof. Hensen's Orthoplanimeter, being an Amsler polar planimeter with which can be combined another fixed arm with a roller. The construction of this instrument is based upon the fact that two strictly parallel rollers placed one after the other are compelled to run in a straight line so as to resist any intentional attempt to cause them to deviate from their rectilinear path. The apparatus is equipped with complete means for ensuring the parallelism of the rollers. By a special sighting apparatus the centres of punctures are located with great accuracy. Straight lines can be measured and drawn accurately within 0.05 mm. The instrument can, therefore, be used for measuring and mapping out curves, for graphic interpolation and even for correcting curves by means of rectangular co-ordinates, especially in such cases where ruled paper cannot be used or does not furnish sufficiently exact results.

X. Appliances for the Examination of Materials and for Special Purposes, Special Tools and Auxiliaries.

1. Fritz Andrée & Co., Limited.

Berlin S.O., 3 Skalitzerstr.

Works: Tempelhof near Berlin, Ringbahnstrasse.

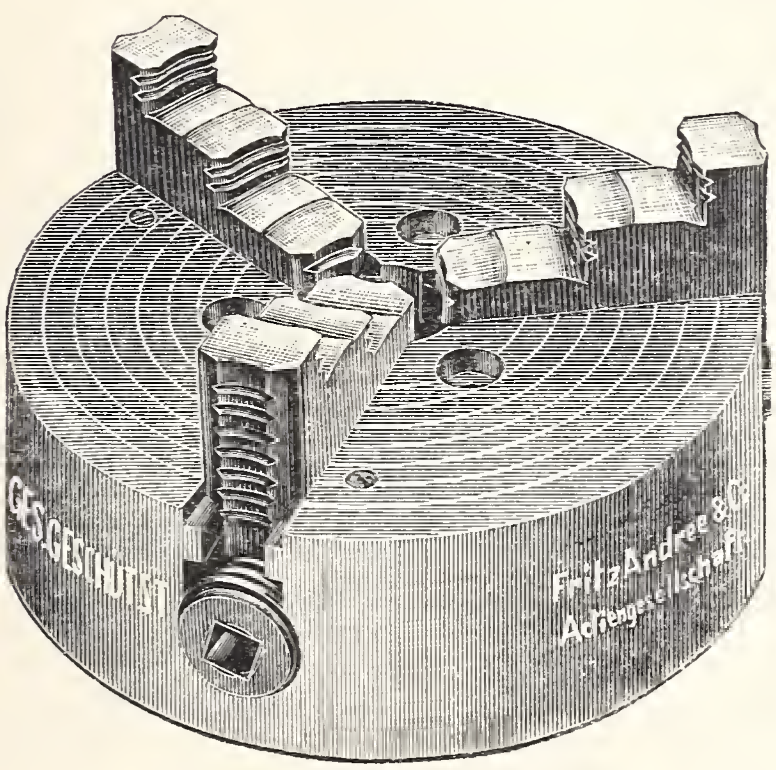


Fig. 1.

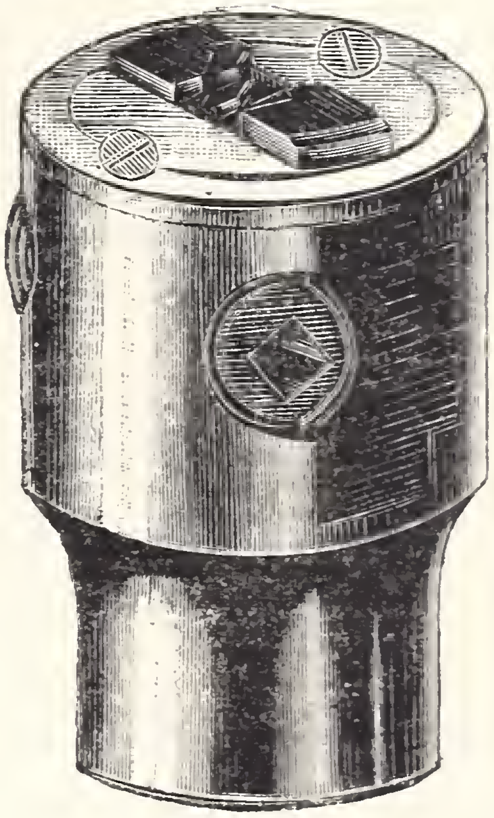


Fig. 2.

1. Lathe Chucks, with self-centreing and excentric grip.
2. Self-centreing Drill Chuck.

These chucks are a speciality of this firm and may be made to order in modified forms to meet existing requirements.

2. Hugo Bieling, Steglitz near Berlin.

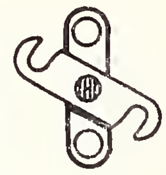
Mechanician.

Speciality: Standard Gauges and Metric Screw-cutting Tools.

1. Officially Certified Standard Screw-bolts and Nuts: single or in sets of 18 fitted in case (Fig. 2).

2. **Stock and Dies**, the latter moving along cylindrical guide-rods. Four sizes (Fig. 1) with quick-opening lock. These stocks and dies are very convenient and made of steel in the best possible manner. The dies are cut by the latest methods and with the greatest care.

Fig. 1.



Lock.

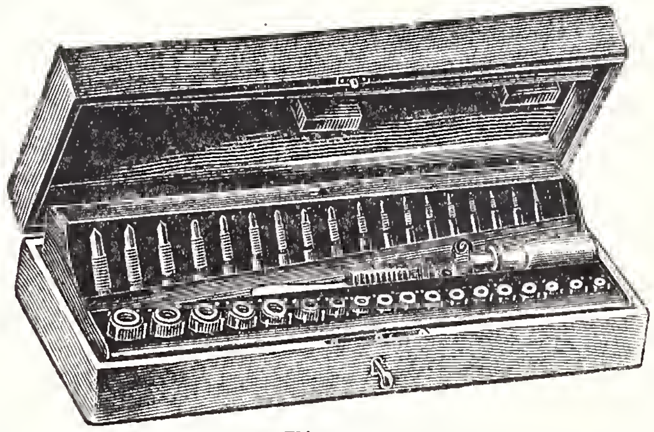


Fig. 2.

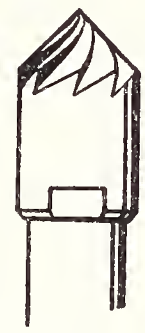


Fig. 3.

3. **Milled Twist-drills.**
4. **Cutting Tools**, cutting well and correctly.
5. **Spirally milled Rose-bit**, with perfect cutting edges up to the point (Fig. 3).
6. **Clock-work Regulators**, of own design.

Special Price-list of Screw-cutting Tools and Standard Gauges.

3. Gustav Halle, Rixdorf near Berlin, 53 Hermannstr.

Maker of Scientific and Technical Instruments of Precision.

(See also Sections Vb, Vc and Vg.)

1. **Double Calipers** (outside and inside), made of aluminium.
2. **Hand Calipers** for outside measurement, made of aluminium; weight 12 g.
3. **Circumferential Gauge, or π-compasses**, made of steel.
4. **Diagonal Calipers**, made of steel.
5. **Pentagonal Calipers**, made of steel.

4. Wilhelm Handke, Berlin N., 12 Lottumstr.

Maker of Instruments of Precision.

1. **Pendulum Clock** beating seconds.
2. **Chrono-chromograph**, registering in type every tenth second.
3. **Chronograph** with electrical driving movement and release.

4. **Key** with indicator for concurrently driving, registering and releasing the two preceding instruments.

These instruments serve conjointly for registering and measuring time in sporting contests.

The seconds beaten by the pendulum clock are marked by contacts upon the tape of the registering instrument which also notes each interval of 10 seconds by imprinting the numbers 1, 2, 3, 4, 5, 6, 1 next to the second points, so as to facilitate the time reading.

The chronograph serves for announcing the winning time. It is set in motion by a triple contact of the second hands, stopped and brought back to "0."

The key is for this purpose provided with a drum indicating these three movements by the inscriptions "0," "Start," "Stop," and after making the contacts "Start" and "Stop" is available for any other registration while the chronograph remains shunted out. The latter is not put into circuit until the drum returns to "0."

The advantage of this construction consists in the absence of the necessity of changing the connections while watching the events.

5. H. Hommel, Mainz.

Maker of Gauge Tools of Precision.

Works: Idarwerk, Oberstein-on-the-Nahe.

Superfine Levels. The casing is made of grey pot-metal and fitted with ground precision aether levels cast in sulphur, with accurately worked edges and finished soles. The levels are parallel longitudinally and the warranted degree of accuracy can be verified.

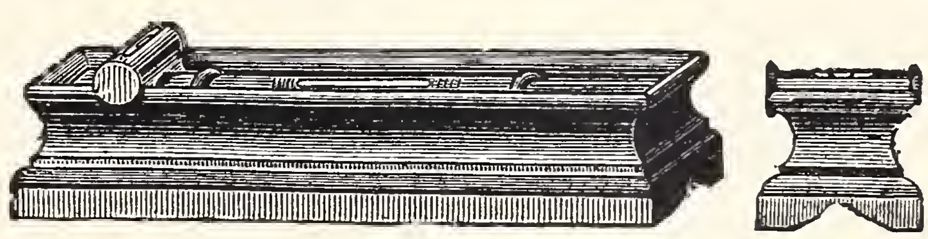


Fig. 1.

1. **Horizontal Level for Shafting,** with v-sole and transverse bubble. Eminently adapted for workshops and for use in erecting plants. Fig. 1.

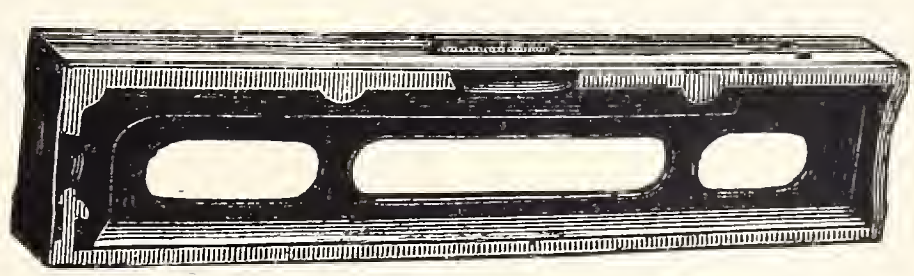


Fig. 2.

2. **Vertical Level,** with horizontal and vertical bubbles, visible from all sides, fitted with correction screws, with smooth sole or v-groove. Fig. 2.

3. **Universal Frame Level** with adjusting screws. All four sides of the iron frame are scraped accurately at right angles to each other for use in horizontal and vertical positions and as a set-square. All four sides are v-grooved for use on round bodies, shafts, &c. Fig. 3.

4. **Combined Level** for crank-pins and shafts. V-grooved longitudinally and at right angles to the length. Fig. 4.

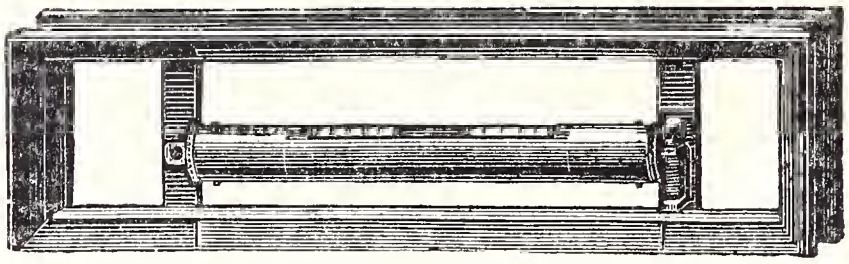


Fig. 3.

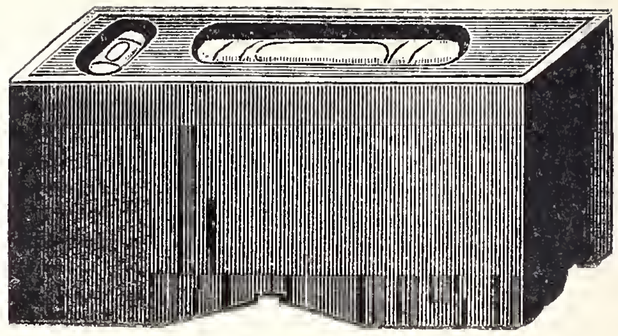


Fig. 4.

5. **Erecting Levels** with v-grooved sole and transverse bubble, in case; consisting of a foot of grey pot-metal and a detachable tubular level 150 mm long, for testing vertical shafting, bearings, cylinders and surfaces, also horizontal bearings and surfaces. Fig. 5.

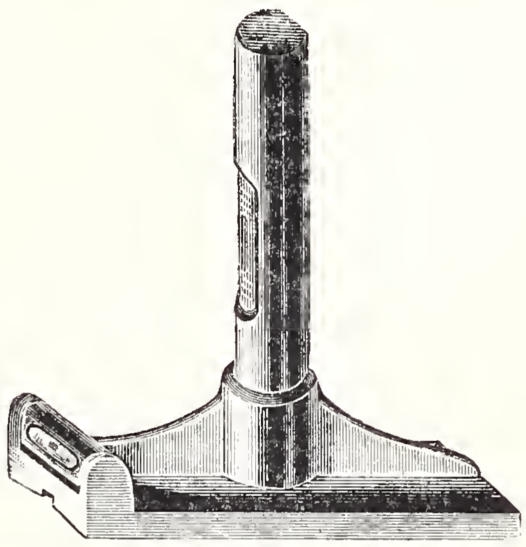


Fig. 5.

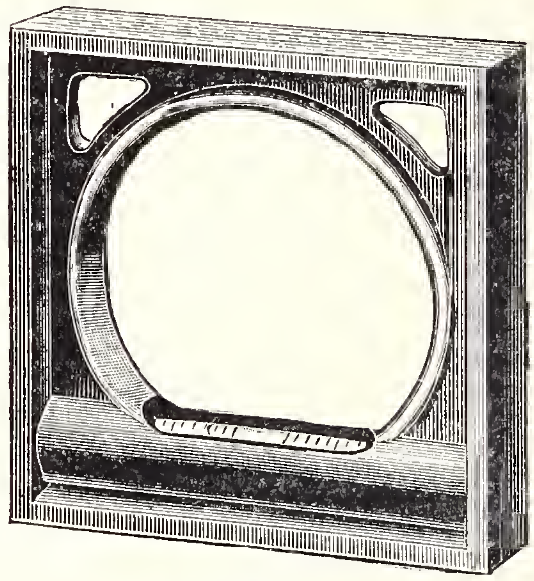


Fig. 6.

6. **Frame Level** with four worked surfaces. All four sides of the square are equal and hence the same degree of accuracy is obtained in side levelling as with horizontal use of the level. Fig. 6.

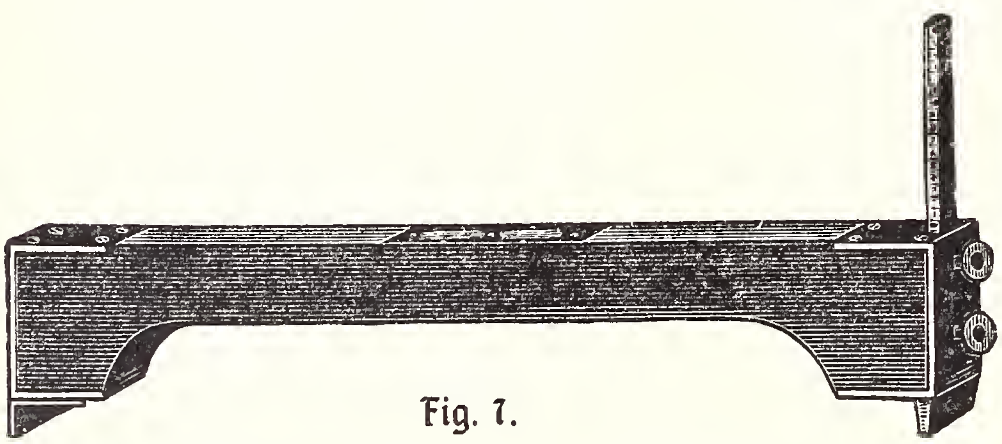


Fig. 7.

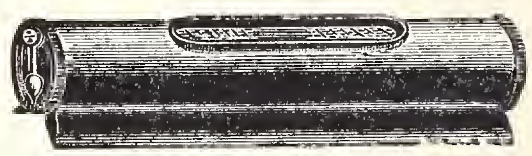


Fig. 8.

7. **Clinometer Level.** Fig. 7. A useful test for pipe laying, canal and earth works. The level is exactly 1,000 mm long and, thanks to its arched form, it can be made to clear obstacles, such as flanges or sockets, which is a very important feature.

8. **Engineer's Pocket Level,** made of aluminium, weighing 60 g only, durable and handy, provided with finely ground and very sensitive aether level. Fig. 8.

9. **Caliper Squares** of steel, simply and exactly made, accurately divided, adapted for vice workers, lock-makers and smiths. Fig. 9.

10. **Caliper Squares** of steel, of stouter make than No. 9, and more highly finished, with hardened jaws, slider with brass sliding strips, adapted for metal turners, engine fitters and mechanicians.

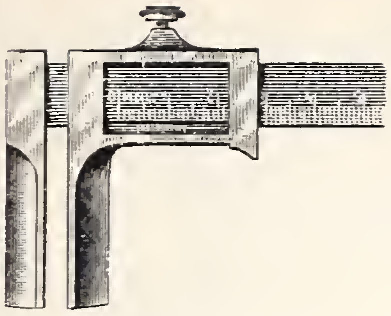


Fig. 9.

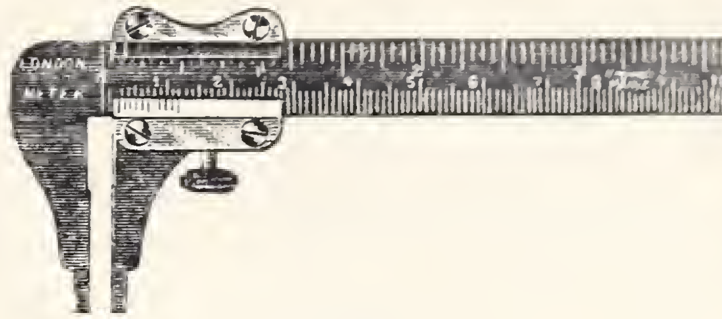


Fig. 10.

11. Pocket Caliper Square, made of cast steel, forged in one piece, with hardened ends for inside measurements, with adjustable slider. This is a most useful pattern. Fig. 10.

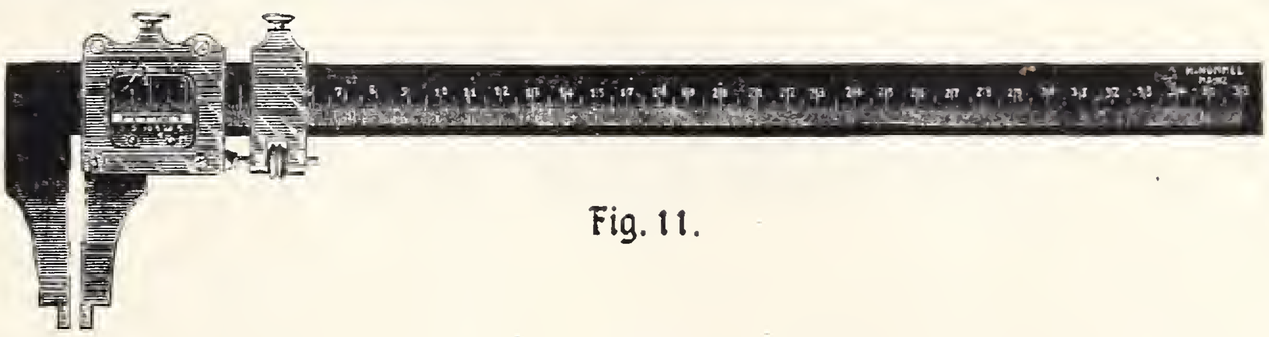


Fig. 11.

12. Fine Micrometer Caliper Square, graduated in the most exact manner and carefully made from excellent material. With micrometer screw, adapted as a standard gauge, with stopped jaw ends for inside measurements. Fig. 11.

13. Fine Micrometer Caliper Square, carefully made of best cast steel and accurately graduated. The end and sliding jaws are forged and the slider is provided with a micrometer follower. Figs. 12 to 15.

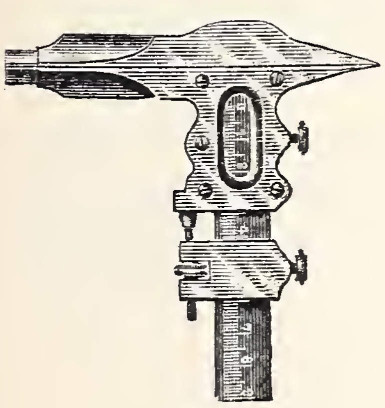


Fig. 12.

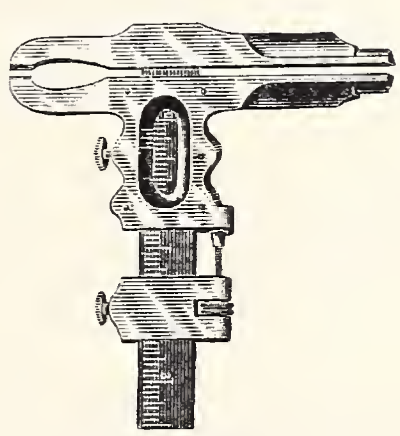


Fig. 13.

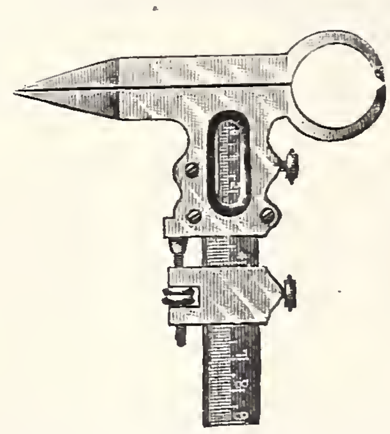


Fig. 14.

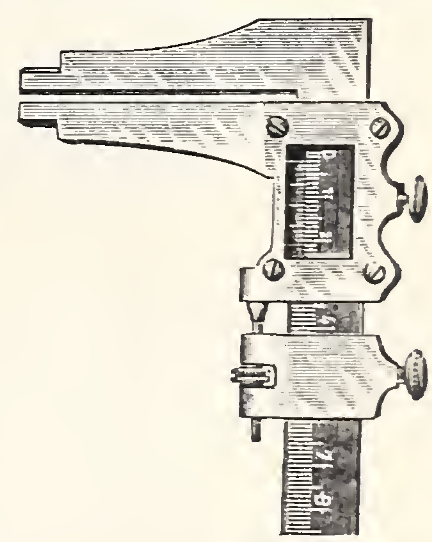


Fig. 15.

14. Micrometer Calipers, Fig. 16, adapted as standard gauges for exact measurements. The bow is made of cast steel, the screw of the best silver steel. The latter is covered so as to exclude dust and dirt. The bow-pin is fitted with a regulating nut so as to take up back lash. The screw has a pitch of 0.5 mm and reads to $^{1}/_{100}$ mm.

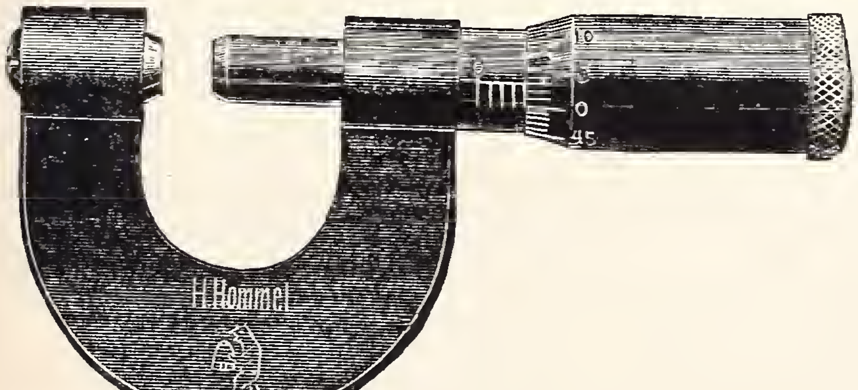


Fig. 16.

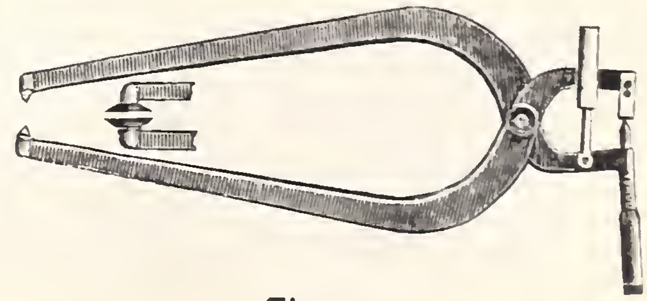


Fig. 17.

15. Micrometer Calipers with long screws without calibrating bodies, finely and accurately made for general workshop use. The bows are round and made of forged cast steel, the micrometer screw is made of the best silver steel and covered so as to prevent the access of dust and dirt. The screw has a pitch of 1 mm and reads to $^1/_{100}$ mm.

16. Micrometer Bow Calipers with large span, Fig. 17, with spring regulator. This gauge is adapted for measuring the stoutness of tubes and other hollow bodies, for gauging the thickness of cardboard lids, paper, metal sheets, leather, India rubber, asbestos, or any other kind of plate or hollow body the thickness of which has to be measured a long distance from the edge.

17. Cylindrical Standard Gauges, Fig. 18, made with great precision of the best tempered cast steel, with projecting cylindrical ends having strictly circular faces. The extreme ends are hardened and are accurately worked within $^1/_{1,000}$ mm.

Fig. 18.

18. Standard Internal and External Cylindrical Gauges, made of the finest special tool steel and finished in a glass-hardened condition. Accuracy is warranted within the limit of ±0.005 mm, at a temperature of 20° C. Fig. 19.

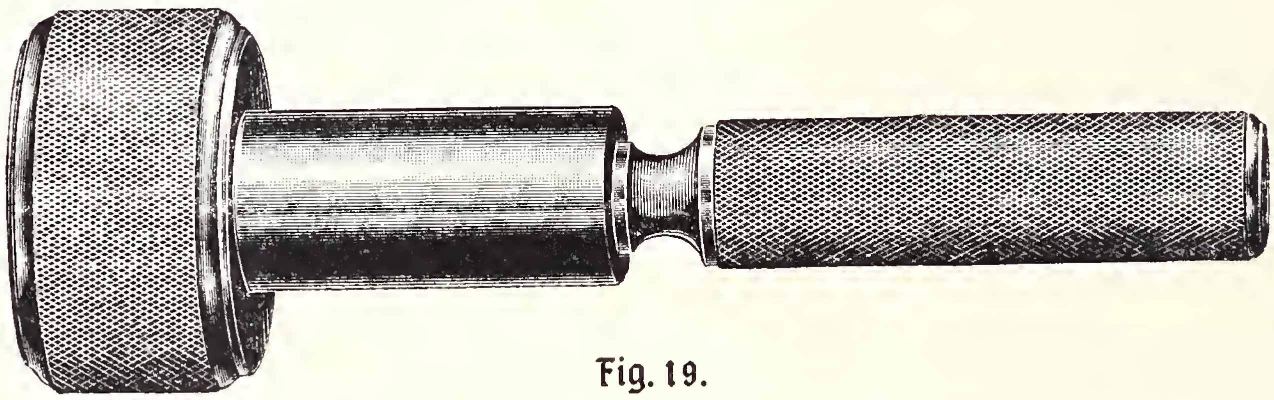


Fig. 19.

19. Cylindrical Male and Female Gauge Bolts, made of the finest special tool steel and finished when glass-hardened accurately within 0.005 mm. This gauge is principally adapted for testing the interchangeable fittings of sewing machines, typewriters, cycles, &c., in fact any machine parts made in large numbers. It also serves to secure the necessary accuracy of all parts required to fit into each other. Fig. 20.

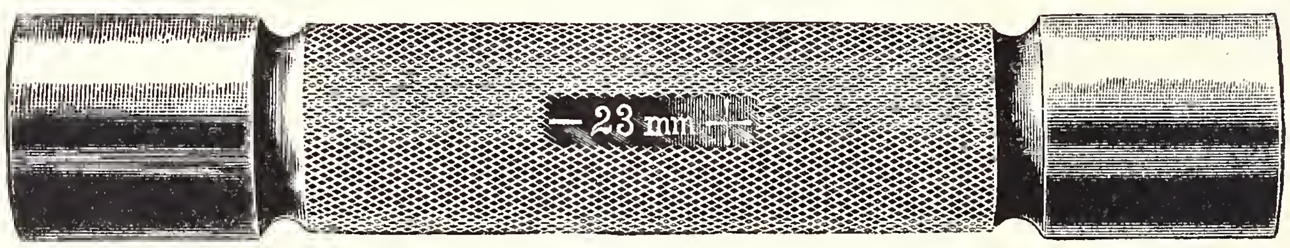


Fig. 20.

20. Standard Metre Measures. Accurately made, with accurately scraped and stoned edges. One side divided in millimetres by fine lines. Being carefully finished these measures are also available as rulers. Fig. 21.

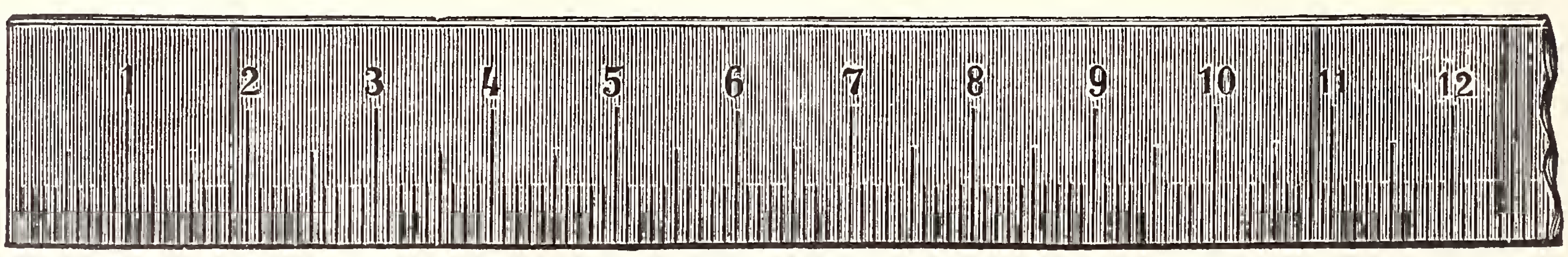


Fig. 21.

21. Standard Metre Measuring Rods, 1,040 mm long, made of tempered special cast steel and having a square section of 20×20 mm. Fig. 22.

Fig. 22.

22. Surface Plates (cast iron standard planes). Fig. 23. These surface plates are made of excellent material having its surfaces absolutely free from flaws. A certain number of these is partly finished and scraped and stored away for some time so as to allow of the equalization of internal strains. Previous to their delivery they receive their final finish, which has been shown by experience to be the only certain method of securing perfect accuracy and at the same time ensuring a prompt supply. The surface plates have unobstructed edges and three resting points and are rubbed symmetrically. When finishing the method is followed of always scraping three plates together.

23. Standard Surface Plates. Fig. 24. For truing up the slide value faces of locomotives and other steam-engines.

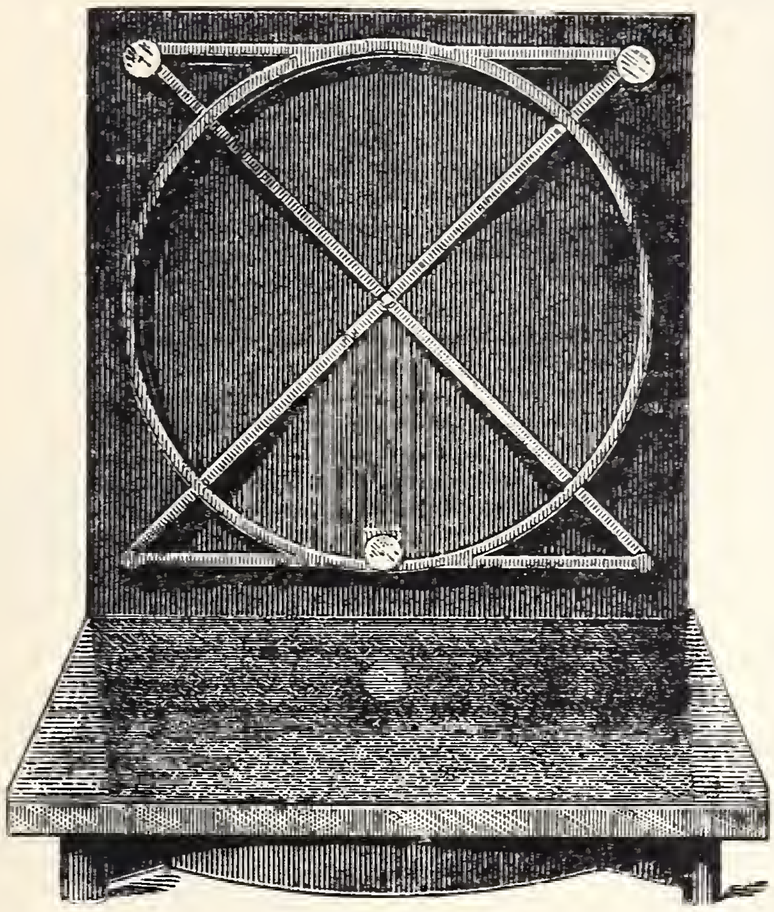


Fig. 23.

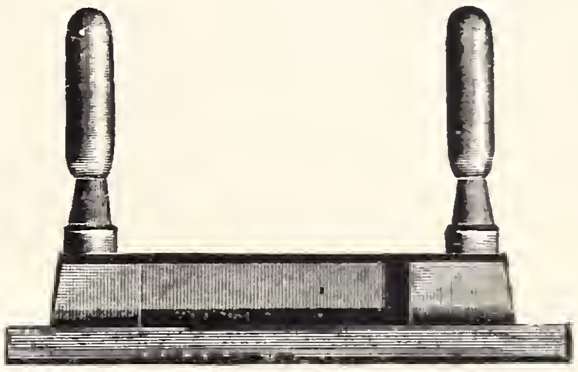


Fig. 24.

24. Standard Cast Iron Straight-edges, Fig. 25, so constructed as to ensure absolute guarantee that it will not undergo any deflection. It is scraped and stoned for truing up machine parts of all kinds, for adjusting hard-cast rollers and is available in all cases necessitating the use of a sufficiently narrow and light surface plate.

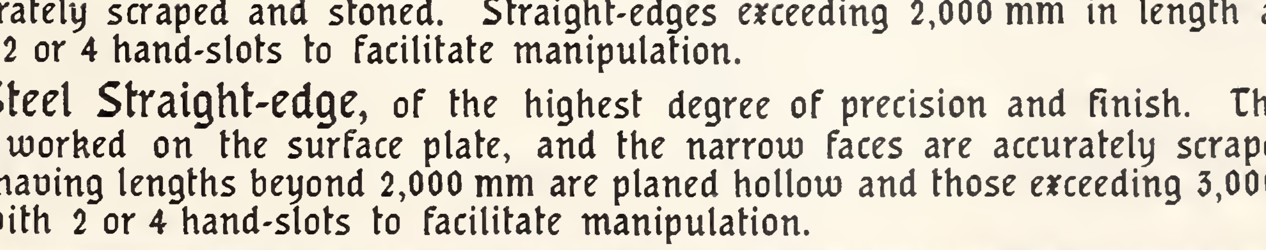


Fig. 25.

25. Standard Cast Steel Straight-edge. Fig. 26. This straight-edge is carefully worked on all sides, accurately scraped and stoned. Straight-edges exceeding 2,000 mm in length are planed and provided with 2 or 4 hand-slots to facilitate manipulation.

26. Cast Steel Straight-edge, of the highest degree of precision and finish. The flat surfaces are accurately worked on the surface plate, and the narrow faces are accurately scraped and stoned. Straight-edges having lengths beyond 2,000 mm are planed hollow and those exceeding 3,000 mm in length are provided with 2 or 4 hand-slots to facilitate manipulation.

Fig. 26.

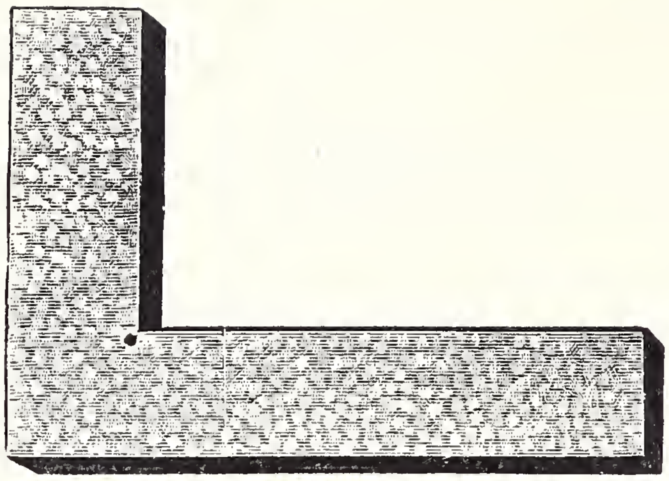


Fig. 27.

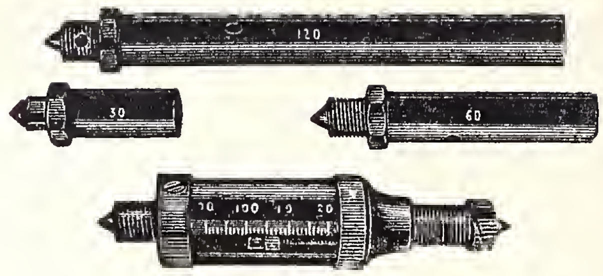


Fig. 28.

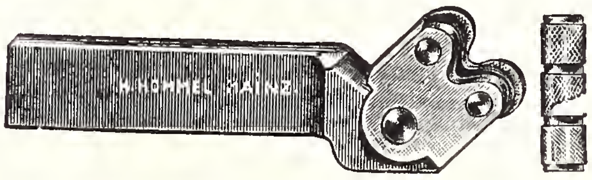


Fig. 29.

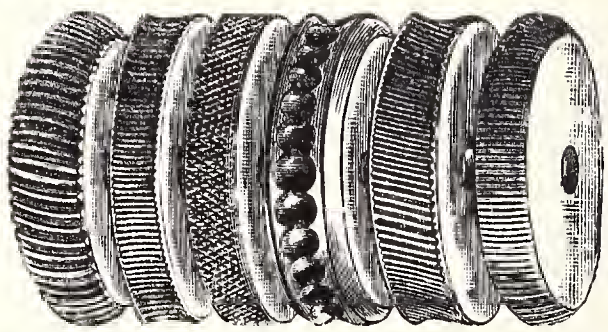


Fig. 30.

27. **Finest Cast Steel Standard Squares**, scraped and stoned on all faces. Fig. 27.

28. **Finest Cast Steel Squares**, for mechanicians, very exactly worked on the surface-plate and provided with accurately scraped edges.

29. **Screw Centre Gauges** with micrometer screw, reading direct to $^1/_{100}$ mm. Size I: 100 to 580 mm. Size II: 330 to 2,330 mm. Fig. 28.

30. **Nurling Tool** for milling round objects. Fig. 29.

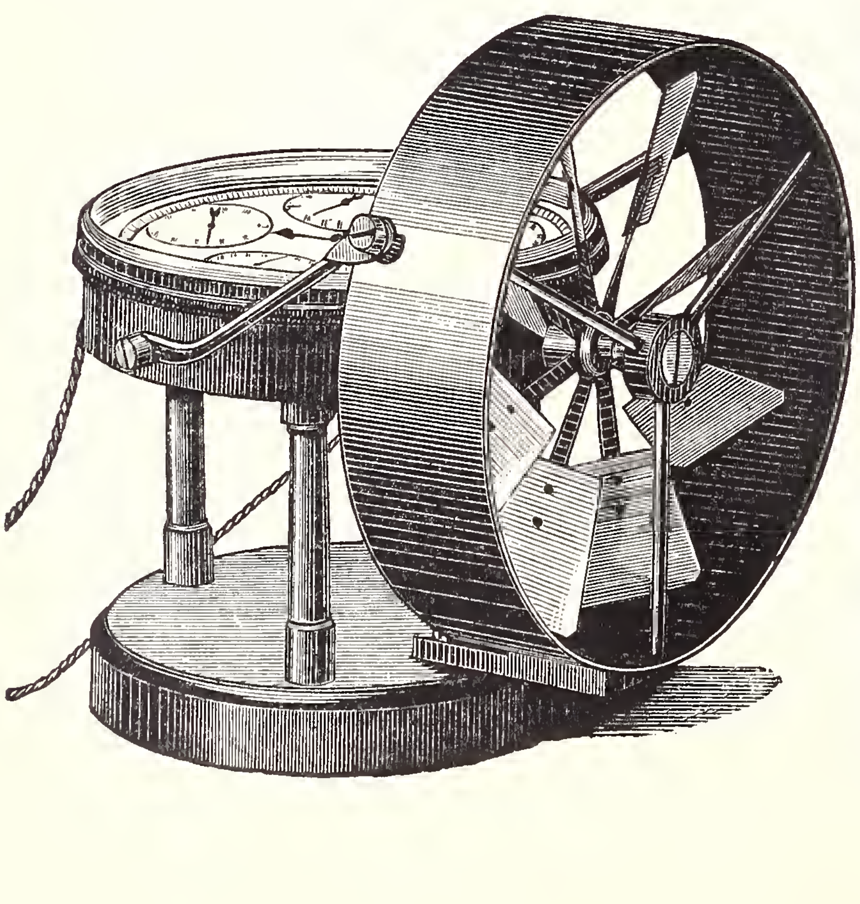
31. **An Assortment of Milling Wheels**, with holder. Fig. 30.

6. Georg Rosenmüller, Dresden-Neustadt.

Speciality: Anemometers for Technical and Scientific Purposes.

Established 25 years.

Awards:—Halle 1881: Bronze Medal. Brussels 1888: 2 Silver Medals. Brussels 1897: Gold Medal.



1. **Anemometer**, counting up to 10,000,000 m with check cord, in stout leather sling case. This anemometer is extensively used in German and Austrian mines.

2. **Anemometer**, counting up to 10,000 m, in wooden case. Chiefly used in architecture and in the ceramic trade.

3. **Anemometer**, similar to No. 2, but larger and extremely sensitive, being capable of measuring air-currents of 6 m per minute.

4. **Anemometer**, having its counting mechanism coupled with a clock in such a manner that the latter, about $^3/_4$ minute after being started, releases the counting mechanism and stops it exactly one minute later, after which the clock stops automatically. Each reading is, therefore, the exact result of one minute. The clock is self-winding and setting. This anemometer is principally used as a check instrument and for measurements in closed shafts.

7. Louis Schopper, Leipzig, 27 Arndtstr.

Mechanician
and Manufacturer of all Appliances and Instruments for Testing Threads, Cloth and Paper, and Appliances for the Official Examination of Grain.

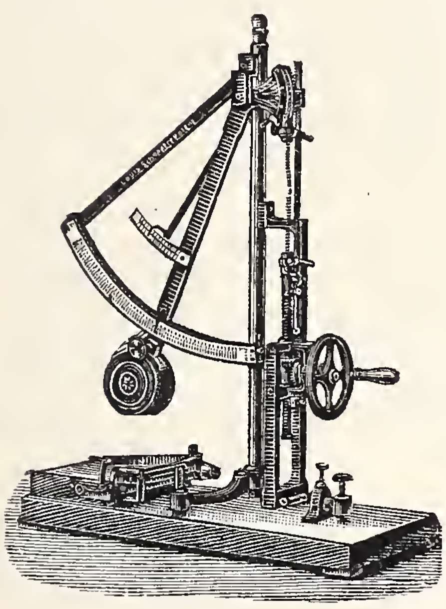


Fig. 1.

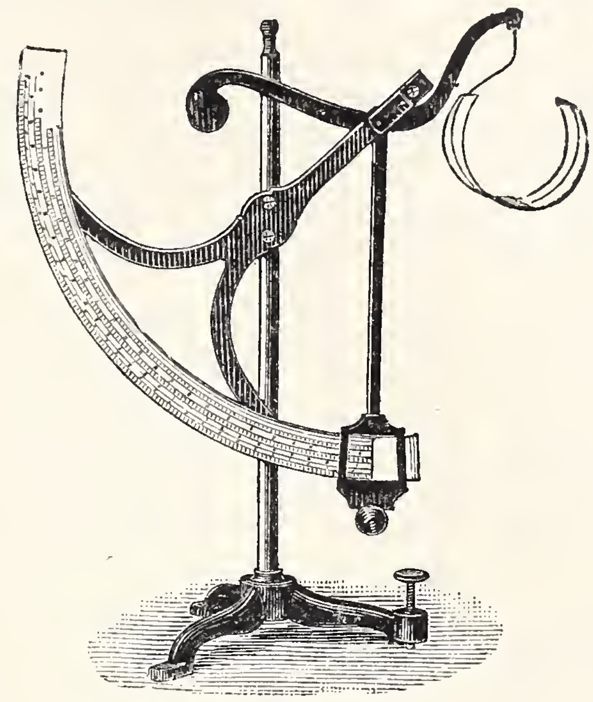


Fig. 2.

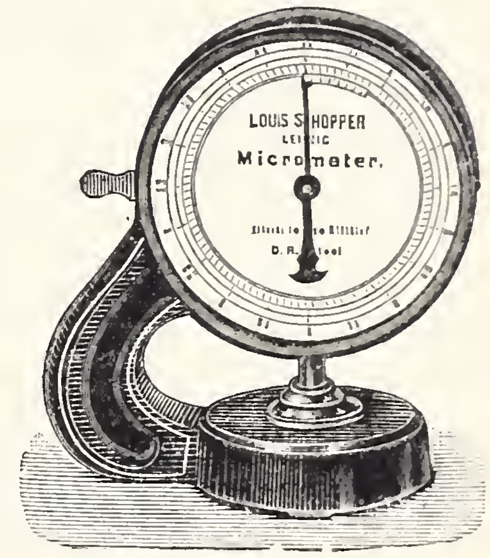


Fig. 3.

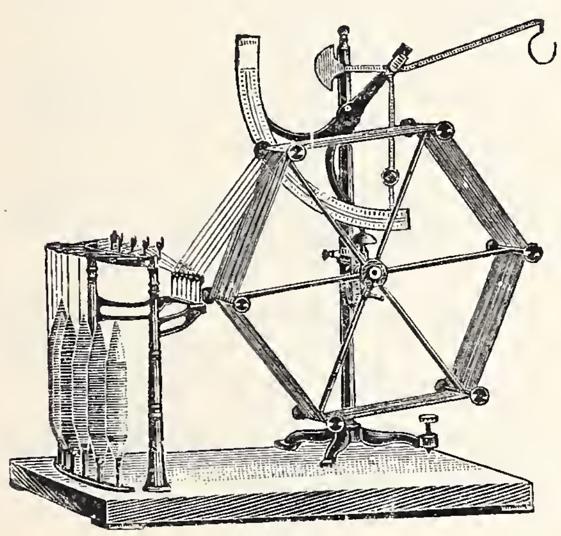


Fig. 4.

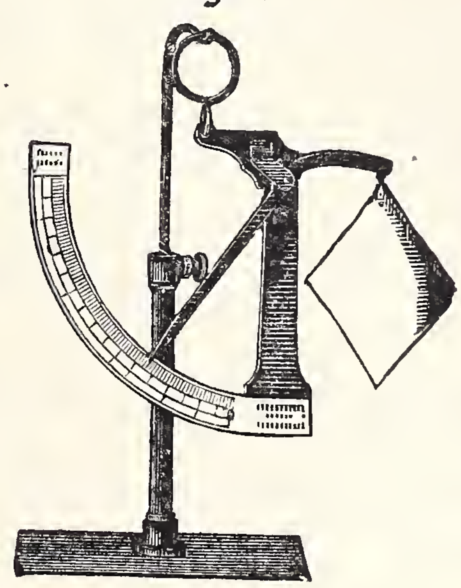


Fig. 5.

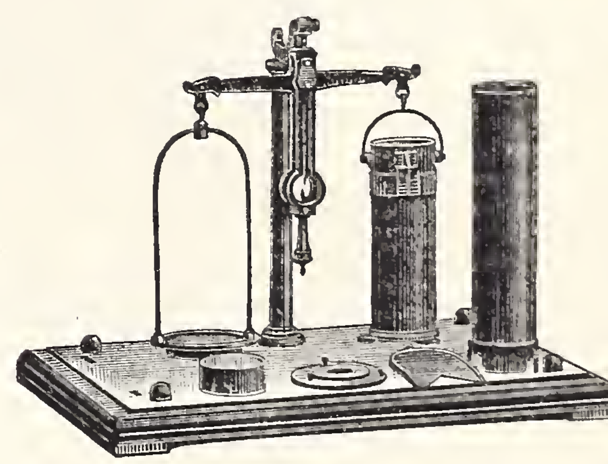


Fig. 6.

1. **Paper Tester** for determining the strength of paper. Fig. 1.
2. **Paper Weigher** for determining the weight per square unit of area. Fig. 2.
3. **Automatic Thickness Gauge.** Fig. 3.
4. **Thread Sorting Balance** with winder for determining the gauge number. Fig. 4.
5. **Balance** for determining the weight of cloth per square unit area by the suspension of small samples.
6. **Grain Tester (Chondrometer),** stationary form, for determining the quality of grains by their specific gravity.

This firm undertakes the supply of the chemicals, reagents, preparing and colouring media required for paper tests. All fibres and mixtures employed in the manufacture of paper are supplied in the form of alcoholic mixtures, comparison and permanent preparations.

Complete Outfits for Testing Paper modelled on the requirements of the Royal Mechanical and Technical Experimental Institute of Charlottenburg (Paper Testing Departments).

German and other patents.—Several awards.—Highest testimonials.—Catalogues free.
Correspondence in German, English, French, Spanish and Italian.

8. Schott & Genossen, Jena.

Glass Works.

Manufacturers of Glass for Scientific and Industrial Purposes.

The Glass Works of Schott & Genossen were founded in 1884 and had their origin in a laboratory established for the experimental fusion of optical and other scientific glasses. The first laboratory experiments made in 1883 and 1884 in conjunction with Prof. Abbe having opened up favourable prospects with regard to the production of new optically valuable glasses, the undertaking was substantially subsidized by the Prussian Government for the purpose of exploiting the preliminary experimental smeltings on a commercial scale, which soon converted the undertaking into a financially independent concern.

Apart from the ordinary crown and flint glasses, the regular manufacture includes a series of new glasses, such as Borate and Baryta, Crown and Flint Glasses, which are extensively used by all leading manufacturing opticians and have furnished the means for many improvements in the construction of optical instruments. We may mention among these:—Improved achromatic microscope objectives, apochromatic microscope lenses, anastigmatic lenses for photographic objectives, telescope lenses without secondary spectrum, new Zeiss prism binoculars (with the aid of colourless prism glass). Optical glasses free from internal tension are produced by a new annealing process.

In the course of time, the manufacture was made to include other glasses, so as to satisfy higher requirements than the usual commercial glasses. Among these may be named:—Jena Standard Glass 16 III (registered trade-mark: a red longitudinal line), and Borosilicate Glass 59 III, for thermometers with diminished secondary depression and an almost unchangeable zero-point. The latter glass (59 III) resists fusion to such a degree as to make it adapted for the manufacture of high temperature thermometers registering up to 550° C.

For laboratory use: Jena Laboratory Glass, capable of resisting sudden changes of temperature and chemical action in an extraordinary degree. Boiling flasks, beakers, retorts. Explosion and combustion tubes, test glasses.

Compound Water-gauge Glasses (German patent No. 61,573) capable of resisting in a high degree sudden changes of temperature and the solving action of hot water and steam.

Jena Incandescent Gas-light and Petroleum-lamp Chimneys, resisting sudden changes of temperature in a hitherto unknown degree. These chimneys will stand, almost without exception, sprinkling with cold water while on the flame.

The glasses made by the Jena Glass Works, in as far as they are finished commercial articles, bear for the protection of the public the firm's stamp.

Exhibits:

Optical Glass: Large objective disks (up to 125 cm diameter) of ordinary crown and flint glasses.—Large objective disks (up to 58 cm diameter) adapted for the construction of telescope objectives without secondary spectrum.—Polished plates of ordinary crown glasses, heavy and heaviest baryta-crown of high refractive power, crown glasses of high and low dispersion. Phosphate and baryta glasses free from silicic acid, baryta light flints, ordinary flint glasses with refractive indices up to 1.9. Also totally reflecting prisms, objective prisms.

Jena Standard and Boro-silicate Glasses for Thermometers.

Explosion and Combustion-tubes for Laboratories.

Compound Water-gauge Glasses.

Jena Glass Laboratory Appliances (boiling flasks, beakers, retorts, reagent glasses).

Jena Incandescent Gas-light and Petroleum-lamp Chimneys.

9. Strasser & Rohde, Glashütte (Saxony).

Chronometer and Scientific Instrument Maker. Established 1875.

Speciality: Accurate Pendulum Clocks.

Highest awards at the Universal Exhibitions of Chicago and Brussels, and at the Trade Exhibitions held at Leipzig and Freiberg.

1. Model of an Escapement for Exact Pendulum Clocks, designed by L. Strasser. This extremely simple escapement impels the pendulum with an unequalled degree of precision. The pendulum is impelled when very nearly in its zero position and the impulsion is independent of the degree of constancy of the driving mechanism and the condition of the oil; it is, however, dependent upon changes in the coefficient of elasticity of the pendulum spring at various temperatures. Its action is therefore absolutely uniform at all temperatures and hence the amplitude of the pendular oscillations remains normal under all conditions. Fig. 1.

Moreover, the escapement enables the pendulum to swing out freely, it acts therefore as a free escapement so as to leave the pendulum unaffected at the extreme points. The movements of all pendulum clocks fitted with this escapement have, in consequence of these properties, acquired a high degree of uniformity.

Fig. 2.

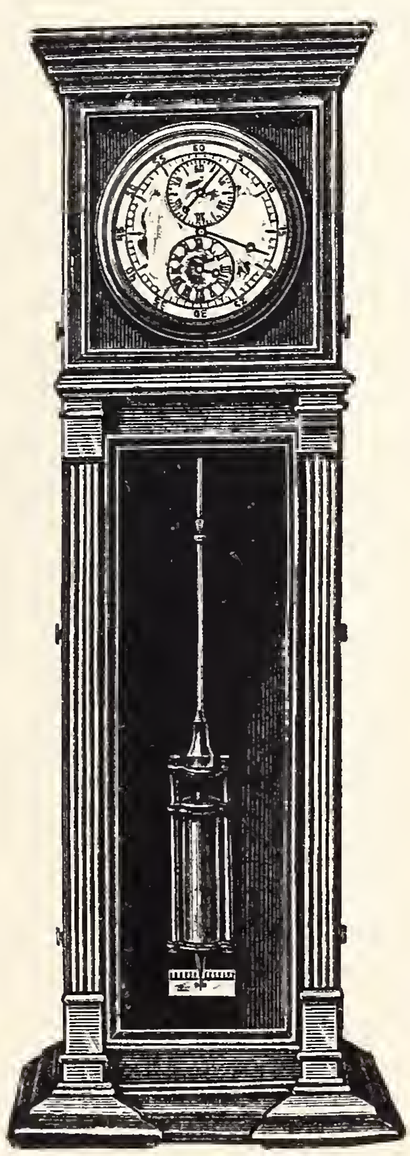


Fig. 1.

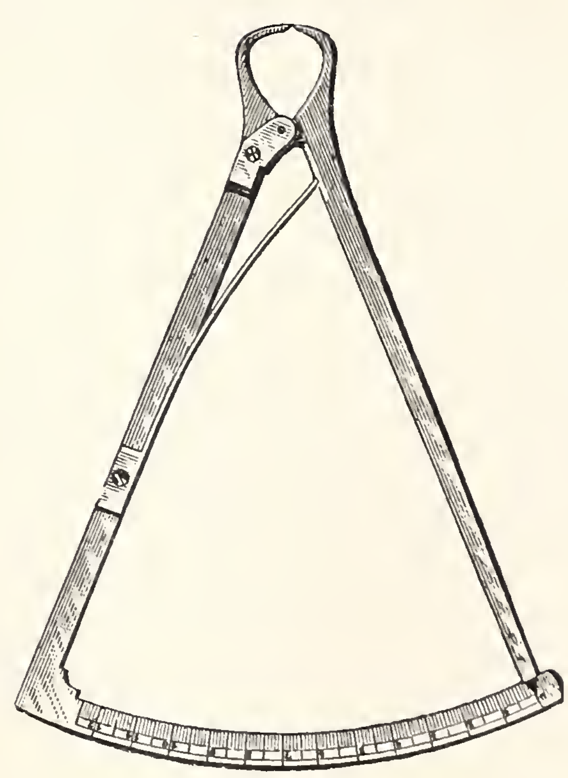


Fig. 3.

2. Measuring Instruments. Figs. 2 and 3. Micrometer gauges adapted for a great variety of scientific and technical purposes, dividing a millimetre into fractions varying from $^1/_{20}$ to $^1/_{1,000}$. $^1/_{20}$, $^1/_{100}$, $^1/_{200}$, $^1/_{500}$, $^1/_{1,000}$ mm can be measured directly with these instruments. Micrometers are also

made reading $^1/_{100}$, $^1/_{1,000}$ and $^1/_{10,000}$ of the English inch. The jaws of these gauges are either made of hardened steel or fitted with sapphires so as to prevent undue wear through continued use. The gearing used in these instruments is made with the utmost care; there is absolutely no play and hence the readings are correct at any position of the index.

10. Ernst Winter & Sohn (late Ernst Winter),

Hamburg-Eimsbüttel, 58 Osterstr.

Maker of Diamond Cutting Tools.

Established 1847.

An Assortment of Diamond Gravers for extremely fine dividing on glass, metal, &c.

Supplement to Section II.

6. O. Töpfer, Potsdam.

See p. 40.

3. Large Star Spectrograph for determining movements within the visual radius. The apparatus in conjunction with a large refractor serves for the photography of highly dispersed star spectra. It is attached to the telescope by means of an adapter rotating so as to describe position angles. The width and breadth of the slit are adjusted micrometrically. The apparatus comprises 3 flint-glass prisms of 60°, producing a total deviation of 162°, the dispersion from D to G being 10°. The length of the camera is shortened with respect to the collimator in the ratio of 4:5. The prism casing is fitted with a controlling telescope for the purpose of keeping a star in view and observing its spectrum during photographic exposure. The photographic lenses are interchangeable with visual objectives for direct ocular observation.

4. Measuring Apparatus, especially for measuring spectrum photograms, mounted on a stand and adjustable so as to place it in the most convenient position for the observer. The micrometer-screw actuating the measuring stage has a pitch of 0.5 mm and a length of 10 mm; it reads to 0.0005 mm. Entire revolutions are counted automatically. The movement of the microscope at right angles to the direction of measurement is capable of measurement. The microscope has a range of magnification from 12 to 750 diameters. The field of view can be limited at pleasure and to any desired extent by turning a collar at the eyepiece end. The readings are taken with the aid of adjustable double cross-lines. Accessory: Apparatus for testing the micrometer screw.

Both instruments are the property of and exhibited by the Prussian Ministry of Education.

Imperial Physical and Technical Institute, of Charlottenburg.

This Institute was founded in 1887 and comprises two departments, upon which devolve the following respective tasks:—

The First Department opens its doors to physical investigations and measurements aiming at the solution of scientific problems of greater theoretical or practical importance and involving a greater expenditure for instruments and materials, or requiring more time for observation and calculation than is ordinarily at the disposal of private individuals or even schools.

The objects of the Second Department are fourfold, viz.:—

1. To carry out physical and technical investigations ordered from time to time by the authorities or such researches as appear calculated to promote the manufacture of scientific instruments or to contribute to the growth of allied branches of German industry.
2. To test and certify measuring and standardizing instruments as far as these operations do not fall within the province of the Office of Weights and Measures; also to ascertain the errors of graduation in such instruments and to issue certificates setting forth the results of these tests.
3. To construct instruments or parts of instruments and to carry out other mechanical work for the requirements of the Imperial Institute or other German Government institutions and authorities, in cases where the work cannot appropriately be carried out in private German workshops.
4. To make and supply certain parts of instruments for the use of manufacturers or traders in special cases where the manufacture in private workshops presents unusual difficulties.

The instruments exhibited are largely of the Institute's own make and serve to illustrate a few of the subjects with which the Imperial Physical and Technical Institute has to deal. Where no maker's name is stated, the instrument has originated in the Institute's workshops.

1. Pachymeter. This instrument serves for the exact measurements of thicknesses, especially the diameters of cylinders. It has been made by J. Wanschaff, of Berlin, from designs by Dr. Leman. Two slides are made to move along cylinders and touch the body which it is required to measure by means of spheres. The slides are fitted with two graduated scales which are read by two micrometer microscopes. The instrument is equipped with the requisite accessories for controlling the parallelism of the axes of the microscopes and the contacts at the apex of the spheres.

The diameter of a cylinder is determined by the measurement of any number of parallel chords of its circular section together with their mutual distances. The latter are shown by a lifting screw with divided head. This instrument has been largely used and proved eminently satisfactory.

2. Large Standard Tuning Fork sounding 435 double vibrations, mounted on sounding box, including case and certificate.

This fork has been designed for the purpose of fixing the international musical pitch and serves for tuning entire orchestras; its construction conforms to the directions issued for the examination and certification of tuning forks. See Zentralblatt f. d. Deutsche Reich 1888. p. 959 and Z. f. Instrk. 9. p. 65. 1889.

3. Small Hand Tuning Fork sounding 435 double vibrations, in case, including certificate.

This tuning fork sounds the international musical pitch, it is adapted for use by hand and likewise conforms to official regulations.

Both forks are exhibited in order to illustrate the method of certification and to give publicity to the form of the certificates. Their maker is H. Heele, of Berlin.

4. Drum Chronograph mounted on a Table. The apparatus is primarily adapted for determining the vibrations of tuning forks as used for scientific purposes. The cylinder is 20 cm in diameter and finely polished; it is smoked when required for use. It is driven by a clock-train so as to rotate uniformly. A standard duplicate tuning fork mounted on a slide is moved along the cylinder by a leading screw so as to inscribe upon it the standard curve of vibrations whilst an electromagnet and lever mounted on the same slide marks the seconds. The tuning fork required to be tested is compared with the standard fork by the method of beats. See also "Ueber die Normalstimmgabeln der Physik.-Techn. Reichsanstalt und die absolute Zählung ihrer Schwingungen" (On the standard tuning forks of the Imp. Phys. and Techn. Inst. and the absolute method of counting vibrations). Z. f. Instrk. 10. pp. 77, 170, 197. 1890.

This chronograph has been made by H. Heele, of Berlin. It is fitted with change wheel gearing so as to cause the drum to rotate at three different speeds. The circumferential velocity of the drum may accordingly be 1, 5 or 10 cm. The movement of the clock is regulated by a centrifugal friction regulator with freely suspended rotating masses as modified by Prof. Young, of Princetown, Mass. See Z. f. Instrk. 6. p. 18. 1886.

5. Standard and Meteorological Thermometers. Unless stated to the contrary, these thermometers are of the encased pattern and made of Jena standard thermometer glass 16^{III}. The 16^{III} glass as well as the hard 59^{III} borosilicate glass, as made at the Jena Glass Works of Schott & Genossen, is absolutely invariable in its quality (see Wiebe, Sitzungsber. d. Berliner Akad., 12. Nov. 1885, and Schott, Z. f. Instrk. 11. p. 330. 1891). In the encased thermometers the expansion of the scale glass is almost identical with that of the 16^{III} glass, whereas the expansion of the borosilicate glass is less (see Gumlich and Scheel, Z. f. Instrk. 17. p. 353. 1897).

The standard thermometers specified below are uniformly graduated regardless of irregularity in the caliber. Reductions of the readings of 16^{III} and 59^{III} glass thermometers to those of the gas thermometer will be found in Grützmacher's paper on "Thermometric corrections," Wied. Ann. 68. p. 769. 1899.

a. A set of Fundamental Standard Thermometers made by R. Fuess of Steglitz, consisting of four thermometers embracing a range of 0 to 300° C., viz.:—

No. 790, divided into 0.1°, from —18 to +51° and from +98 to 102°, 1 degree equal to 4 mm on the scale;
- 791, - - 0.1°, - — 2 - + 2° - - +46 - 102°, 1 - - - 4 - - - -
- 792, - - 0.2°, - — 4 - + 2° - - +93 - 208°, 1 - - - 2.5 - - - -
- 793, - - 0.5°, - — 5 - + 3°, from +94 to 103° and from 193 to 303°, 1 degree equal to 2.5 mm on the scale.

b. Standard Thermometer No. 511 made by C. Richter, of Berlin, divided into 0.1° from —2 to +102°, 1 degree equal to 4.5 mm on the scale.

c. Standard Thermometer No. 512 made by C. Richter, of Berlin. This thermometer is made from Jena glass 59^{III}, and graduated on the rod into 0.1° from —2 to +102°, each degree equal to 5.5 mm.

d. Standard Thermometer No. 800 made by R. Fuess, divided into 0.1° from —40 to +2°, from +32 to 34°, from 65 to 67° and from 98 to 101° C., one degree equal to 4 mm.

e. Boiling Point Apparatus[1] for altitude measurements, together with boiling point thermometers made by R. Fuess.

The thermometers are made of 59^{III} glass and divided, in accordance with the tension curve of water vapour as shown in Wiebe's table (published by Fr. Vieweg & Sohn, Brunswick, 1894), into intervals of 2 mm ranging from 370 to 820 mm. The height of the barometer can be read directly with their aid.

The water of the apparatus is protected from overheating by a specially constructed boiler, and the same applies to the steam space (see Grützmacher, Z. f. Instrk. 17. p. 193. 1897).

6. Thermometers for Scientific Purposes (Laboratory Thermometers).

a. 3 Thermometers for measuring low temperatures:—

1 Petroleum-aether Thermometer made by C. Richter, of Berlin, 30 cm long, divided into single degrees on the rod, and ranging from +20 to —170° C., as suggested by F. Kohlrausch, "Ueber ein Thermometer für sehr tiefe Temperaturen und über die Wärme-Ausdehnung des Petroläthers" (On a thermometer for very low temperatures and on the thermal expansion of petroleum-aether). Wied. Ann. 60. p. 1. 1897.

1 Toluol Thermometer made by C. Richter, divided into single degrees from +50 to —100° C.

1 Alcohol Thermometer made by R. Fuess, divided into 0.5° from +10 to —90° C.

The graduations of these thermometers are based upon the scale of a gas thermometer.

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[1] This apparatus has been lent to the Institute for exhibition by its maker.

b. 2 Auxiliary Thermometers for determining the temperature of the protruding column of mercury thermometers (filament thermometers) made by C. Richter, divided from —40 to +300°, with vessels 10 and 20 cm long.

These thermometers were originated by Guillaume and, as now shown, modified by Mahlke (Z. f. Instrk. 13. p. 58. 1893). The auxiliary thermometer is placed along the protruding column of the principle thermometer in such a manner as to cause its zero point to be in the vicinity of the top of the mercury filament, by which means the required temperature of the latter can be found directly from the scale of the auxiliary thermometer.

7. **High Temperature Thermometers** (up to +575° C.). Mercuric thermometers capable of measuring temperatures up to 450° C. by placing the mercury under a pressure of about 4 atm. were used as early as 1844 by Person. It appears however that thermometers of this kind did not come into further use previous to the introduction of the highly refractory 59 III borosilicate thermometer glass.

All these thermometers have been made and graduated on the stem by W. Niehls, of Berlin, and the space above the mercury is filled with dry carbonic acid at a pressure of about 20 atm. The graduations are burnt into the stem by Niehl's process. The method by which these thermometers are made has been described by Mahlke in the Z. f. Instrk. 12. p. 402. 1892. Instead of carbonic acid, dry nitrogen may be employed as a filling medium. One of the thermometers exhibited is made of Jena combustion tube glass, another of 16 III glass, the remainder of 59 III glass. The first is harder still than the 59 III glass and thermometers made with it can be heated to a temperature of 575° C. The borosilicate thermometers are available for exact measurements up to 550° C., those made of 16 III glass for temperatures up to 420° C.

The readings of these thermometers have been calibrated by an air thermometer (see Mahlke, Wied. Ann. 53. p. 965. 1894).

a. 1 Thermometer No. 4,150 of 16 III glass, divided into single degrees from —5 to +430° C.

b. 1 Thermometer No. 4,160 of 59 III glass, divided into single degrees from —5 to +5 and from +195 to 550°.

c. 1 Thermometer No. 4,170 of Jena combustion tube glass, divided into single degrees from —10 to +10° and from +195 to 580° C.

d. 1 Standard Thermometer No. 4,200 of 59 III glass with uniformly divided scale (1 mm = 0.5°) from —5 to +5°, from +98 to 102°, from 198 to 202°, from 298 to 302° and from 385 to 550° C.

In this thermometer the correction is ascertainable through fundamental observation in the thermometer itself.

e. Two Filament Thermometers made of 59 III glass, graduated on the stem at intervals of 10 degrees from 0 to 450° C. The bulbs are respectively 10 and 20 cm long.

8. **Le Chatelier's Thermo-electric Couple** of platinum-rhodioplatinum, the latter being an aloy containing 10 per cent of rhodium. The couple, 3 m long and 0.6 mm in diameter, has been selected from about 9 kg (or 1.5 km) of wire supplied by W. C. Heraeus, of Hanau, to the Imperial Physical and Technical Institute for the purpose of being tested: The individual thermo-electric couples composed of electrically annealed pieces of this wire vary in their thermal values scarcely 3° at a temperature of 1,500° C. The test values of the E. M. F. in terms of degrees of the gas-thermometer noted on the certificate supplied with the couple have reference to Holborn's and Wien's scale (Wied. Ann. 56. p. 395. 1895). The Imperial Institute has so far tested and certified upwards of 1,000 thermo-electric couples of this kind, which were as a rule 3 m long.

9. **Electrical Furnace** for testing thermo-electric couples at high temperatures. The furnace consists of a series of concentric tubes of fire-proof porcelain (Mass No. 7, supplied by the Royal Porcelain Factory, of Charlottenburg), separated from each other by layers of fire-clay and air. One of these rings is threaded and carries the heating wire through which the electric current passes (for temperatures up to 1,400° it is made of nickel, up to 1,600° of platinum-iridium). The thermo-electric couples which are to be compared are placed within the tube, where they are kept apart by their porcelain capillaries and screened from the external influence of the heating current by an outer envelope which rests merely on the cold ends of the furnace. This envelope is indispensable at high temperatures, where porcelain loses its isolating power. The furnace consumes about 1,400 watts at 1,300°.

The thermo-electric couples are tested by comparison with several standard couples connected with the gas-thermometer. The heated junctions within the furnace are attached to a small disk of platinum-rhodium, whereas the cold junctions are immersed in a bath of petroleum agitated by a stirring apparatus and maintained at the ordinary room temperature or, if the couples differ considerably from each other and also if exact results are required, at the temperature of melting ice. See "Thätigkeitsbericht der Physikalisch-Technischen Reichsanstalt für 1898." (Report of the work carried out during 1898 by the Imperial Physical and Technical Institute.) Z. f. Instrk. 19. p. 249. 1899, and Holborn and Day, Wied. Ann. 68. p. 817. 1899.

10. Shunt for Testing Thermo-electric Couples, &c. after Lindeck[1]. Le Chatelier's thermo-electric couples have in late years been tested by the Imperial Physical and Technical Institute in very considerable numbers. By means of the apparatus exhibited the electromotive form of the couples can be read without calculation. The compensating shunt, which is the leading feature of the apparatus, is shown in Fig. 1. The current supplied by an accumulator A is regulated by the adjustment of the resistance W which causes the loss of potential produced by a known resistance, e. g. 0.1 ohm, to compensate the thermo-electromotive force of the couple T. M is a sensitive milli-ampèremeter, the readings of which, divided by 10, indicate the electromotive force of the thermo-electric couple, supposing the shunt resistance to be 0.1 ohm. The apparatus includes several shunt resistances of 0.05, 0.10, 0.15 ohm, &c., so as to provide for the utilization of the full scale of the milli-ampèremeter.

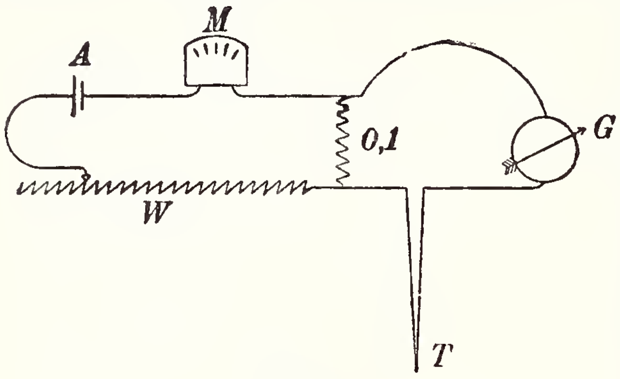

Fig. 1.

The apparatus is likewise adapted for work with other couples besides those of Le Chatelier, e. g. for the measurement of low temperatures with the aid of a constantan-iron couple; in fact, for measuring low potentials in general, which in this apparatus may reach 0.06 volt. See Lindeck and Rothe, Wiss. Abh. d. Reichsanstalt 3.

11. Air-thermometer Vessel of Platinum-iridium filled with nitrogen, as employed by L. Holborn and A. Day for measuring high temperatures; see "Ueber die Luftthermometer bei hohen Temperaturen" (On air-thermometers at high temperatures), Wied. Ann. 68. p. 817. 1899. The vessel is 17 cm long, its diameter 4 cm, its capacity about 200 ccm and its walls 1 mm thick. The capillary is 30 cm long and its internal diameter is 0.7 mm. The vessel is made by W. C. Heraeus, of Hanau.

12. Small Electric Muffle Furnace of the German Gold and Silver Refining Works, Frankfort-on-the-Main, for the examination of smelting samples. The heating current passes through a platinum wire netting enveloping the muffle.

13. Fluid Thermostat with Electric Heating Apparatus for comparing thermometers. A vessel of Jena laboratory glass (by Schott & Genossen, Jena) serving as a receptacle for the fluid is placed, and can be rotated, in a cylinder composed of several concentric envelopes separated by air spaces. The interior of the vessel is occupied by a turbine the envelope of which carries the heating arrangement. The latter consists of two electrically heated coils of constantan wire which are wound side by side upon a threaded clay tube. These coils may be put into circuit, in series, singly or in multiple arc, according to the intensity of the required temperature, while the strength of the current is regulated by an outside resistance coil. Suitable fluids are petroleum for moderate, or palmine for higher temperatures. The thermometers are attached to an aluminium cover by means of corks. At temperatures up to 200° C. the reading should be taken with the filament entirely submerged, at higher temperatures (up to 300° C.) the scale may be read just above the surface of the fluid, as in this case the requisite correction does not exceed a few hundredths of a degree owing to the slight difference of temperature. The degree of constancy attainable with this apparatus at 150° C. is never less than 0.01° for a period of 10 minutes, the mean consumption of energy being 300 watts. See R. Rothe, Z. f. Instrk. 19. p. 143. 1899.

14. Dewar's Vessels with Evacuated Jackets, made by R. Burger, of Berlin.

a. Spherical vessel, silvered, 20 cm in diameter and having a capacity of 3 litres, for storing liquid air.

b. Cylindrical vessel of 10 cm diameter, with transparent sides for watching thermometers. This vessel may be used as a thermostat for high temperatures (not exceeding 300° C.) in conjunction with an electrically heated wire coil.

15. Cylindrical Rods of pure platinum, palladium, rhodium and iridium, 1.6 cm in diameter and 27 cm long, lent by W. C. Heraeus, of Hanau. These rods were employed in the determination by F. Kohlrausch's method of the heat conducting power of these metals. See Sitzungsber. d. Berl. Akad. 38. pp. 711 and 719. 1899.

16. Optical Bench with Lummer and Brodhun's Photometer Head,[2] with velvet screens for the exclusion of extraneous light, and rails for connecting two photometer carriages. The graduated track is 250 cm long. The photometer head is adapted for equality and contrast adjustments. See Z. f. Instrk. 9. pp. 23 and 461. 1889; 10. p. 119. 1890; 12. p. 41. 1892.

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[1] This apparatus has been constructed by Mssrs. Siemens & Halske and lent, for exhibition, to the Imperial Institute.
[2] The optical bench with photometer head has been lent for exhibition by Mssrs. Schmidt & Haensch, of Berlin.

17. Street Photometer, for photometrical measurements outdoors and in the laboratory at any angle of emission. A small incandescent lamp constitutes the comparison standard. The measurements are made after the method of rotating sectors, in this case however the sector is fixed whereas the rays passing from the luminant to the photometer field are made to rotate by means of prisms. See Z. f. Instrk. 14. p. 310. 1894.

18. Rotating Photometer Sector, on which the position of the sectors is altered and the circle read while rotating. See Z. f. Instrk. 16. p. 299. 1896; 17. p. 10. 1897.

19. Apparatus for Determining the Position of the Optic Axis in quartz plates ground nearly at right angles to their optic axis, saccharimeter plates in particular, after the method of Gumlich. See Wiss. Abh. d. Reichsanstalt 2. p. 201. 1895. Even in very thin plates, not exceeding 0.4 mm or 25° of Ventzke's scale, it is possible to ascertain the position of the axis within 6 seconds.

20. Surface and Linear Bolometers for measuring total and spectroscopically decomposed radiation. In this instrument particular care has been taken to render both, or all four, arms of Wheatstone's bridge, which is formed by the bolometers, as similar as possible with respect to their resistance and the nature of their surfaces. They consist of platinum strips 0.001 mm thick welded between two strips of silver 0.01 mm thick and subsequently rolled into strips of this thickness, whereby a high degree of uniformity is ensured, the method being analogous to Wollaston's process as applied to wires. These strips are accurately divided on the engine so as to maintain as exactly as possible the proper length and width of the bolometer strips. After mounting the strips upon frames of slate and providing them with terminals the silver is removed by means of nitric acid and the platinum strip is coated electrolytically on both sides with platinic black of great absorbing power.

By this method it has been possible to produce bolometers of any form and resistance and of a thickness down to 0.3 μ.

Having a thickness of only 0.001 mm, these bolometers are extremely sensitive, since differences of temperature are rapidly equalized.

Owing to the identity of the bolometer arms the galvanometer yields a good position of rest even with variable currents. See Wied. Ann. 46. p. 204. 1892.

21. Mercuric Arc Lamp with Water Cooler. This lamp is a modification of Arons's mercury arc lamp (Wied. Ann. 47. p. 767. 1892), which has been given the form shown in Fig. 2, so as to render the intense light of the mercury arc with its few spectrum lines available for polarimetric work. Arons's lamp is adapted for use with weak currents only, as powerful currents are liable to cause the U-tube to become overheated and crack at the point where the arc passes over. By immersing the lamp in water it is possible to maintain the current for hours, but on the other hand a large quantity of mercury vapour is condensed upon the walls of the tube and the drops of mercury while running down cause the intensity of the light to diminish and oscillate continually.

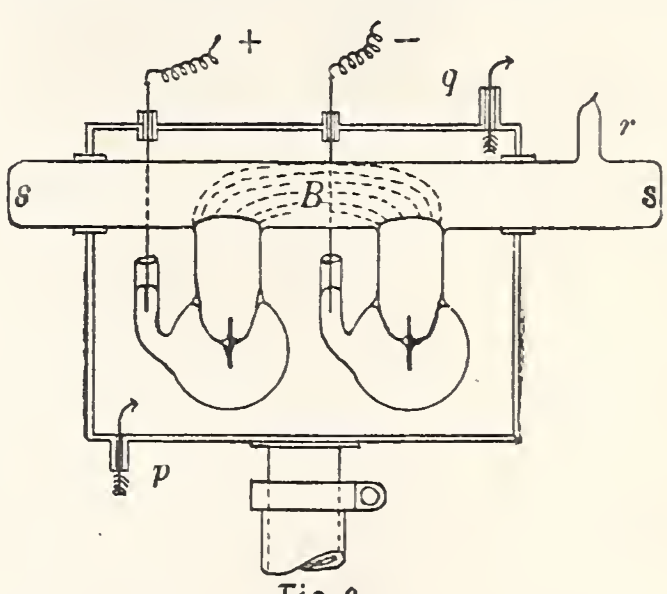

Fig. 2.

These objectionable features are entirely absent in the apparatus as sketched in Fig. 2. In this form of the lamp the line of vision passes through the entire length of the arc B. The light emitted by the arc is diffused and reflected by the matted sides of the horizontal tube and can pass out without hindrance through the ends s. In order that these may be as free as possible from condensed globules of mercury the tube is immersed in water in such a way as to allow the ends of the tube to project being thus cooled less than the intermediate portion. If nevertheless, in the course of time, the end surfaces should become covered with fine globules it is only necessary to carefully tilt the lamp, when the bulk of the mercury coming in contact with the fine deposit will take the latter with it on flowing back. See Beiblatt z. Z. f. Instrk. 1896. No. 4 et seq.

22. Gumlich's Mercuric Arc Lamp Charged with Cadmiumamalgam, together with its heating box. The amalgam contains 5 to 10 per cent of cadmium and, in a fused condition, is filtered through several capillary tubes into the previously warmed and evacuated lamp so as to free it from the layer of oxide which otherwise would prevent the formation of an arc. When in use the lamp is heated in a water bath to about 100° C. and fed by a current of about 10 ampères. The spectrum shows, in addition to the mercury lines, the principal cadmium lines with sufficient brightness for many measurements. See Z. f. Instrk. 17. p. 161. 1897; Wied. Ann. 61. p. 401. 1897.

23. **Electrically Heated Absolutely Black Body,** by Lummer and Kurlbaum. Lummer and Wien have suggested as a suitable means for practically realizing, with any desired degree of approximation, a radiating "absolutely black body," as defined by G. Kirchhoff, that the interior of a hollow body should be raised to as uniform a temperature as possible and that the rays should be allowed to pass out through an aperture (Wied. Ann. 56. p. 451. 1895). Many attempts to realize this suggestion have resulted in the construction of an electrically heated black body, which is available for a wide range of temperatures, besides being easily heated. It is prepared by the following process:—

A piece of platinum foil about $^1/_{100}$ mm thick and 50 cm long is bent into a cylinder and both longitudinal ends are welded together, care being taken to make the section of the cylinder as uniform as possible. Both ends of the tube are thickened and provided with platinum ears through which the electrical current is made to enter the cylinder. The object of the thickening is to cause the current to flow through the cylinder in a direction parallel to its axis. The platinum cylinder contains a thin-walled tube made of a refractory mass and fitted with cross walls and diaphragms, such that only the middle section of the cylinder serves as a radiant. The temperature of the radiant cavity is ascertained by means of a thermo-electric couple. The refractory mass of which the inner tube is made to consist can be heated to nearly 1,700° C. without becoming soft, it is readily moulded and shrinks in a far less degree than porcelain. The tube has been made at the Royal Porcelain Factory, of Charlottenburg. See Verh. d. Physik. Ges. zu Berlin 17. p. 106. 1898.

24. **High Potential Battery of Small Accumulators** of 1,000 volts, made by M. Bornhäuser, of Charlottenburg.

25. **Battery of Small Accumulators** of 240 volts, for measuring purposes, made by M. Bornhäuser, of Charlottenburg.

These batteries consist of lead accumulators in glass jars 9 cm high × 4 cm diameter. Each cell has a positive and a negative electrode and is designed for a normal current of 0.1 ampère and a capacity of 10 hours. The glasses are fitted with an acid-proof stopper which prevents acid from being thrown up by the evolution of gas while the accumulators are being charged. The outside of the jars and their surroundings remain therefore dry.

These cells were first employed by the Imperial Physical and Technical Institute with a high potential battery of 11,000 volts, which has now been in use for 5 years. See lecture by K. Feussner, Hochspannungsbatterien (High potential batteries), Elektrotechn. Zeitschr. 20. p. 632. 1899.

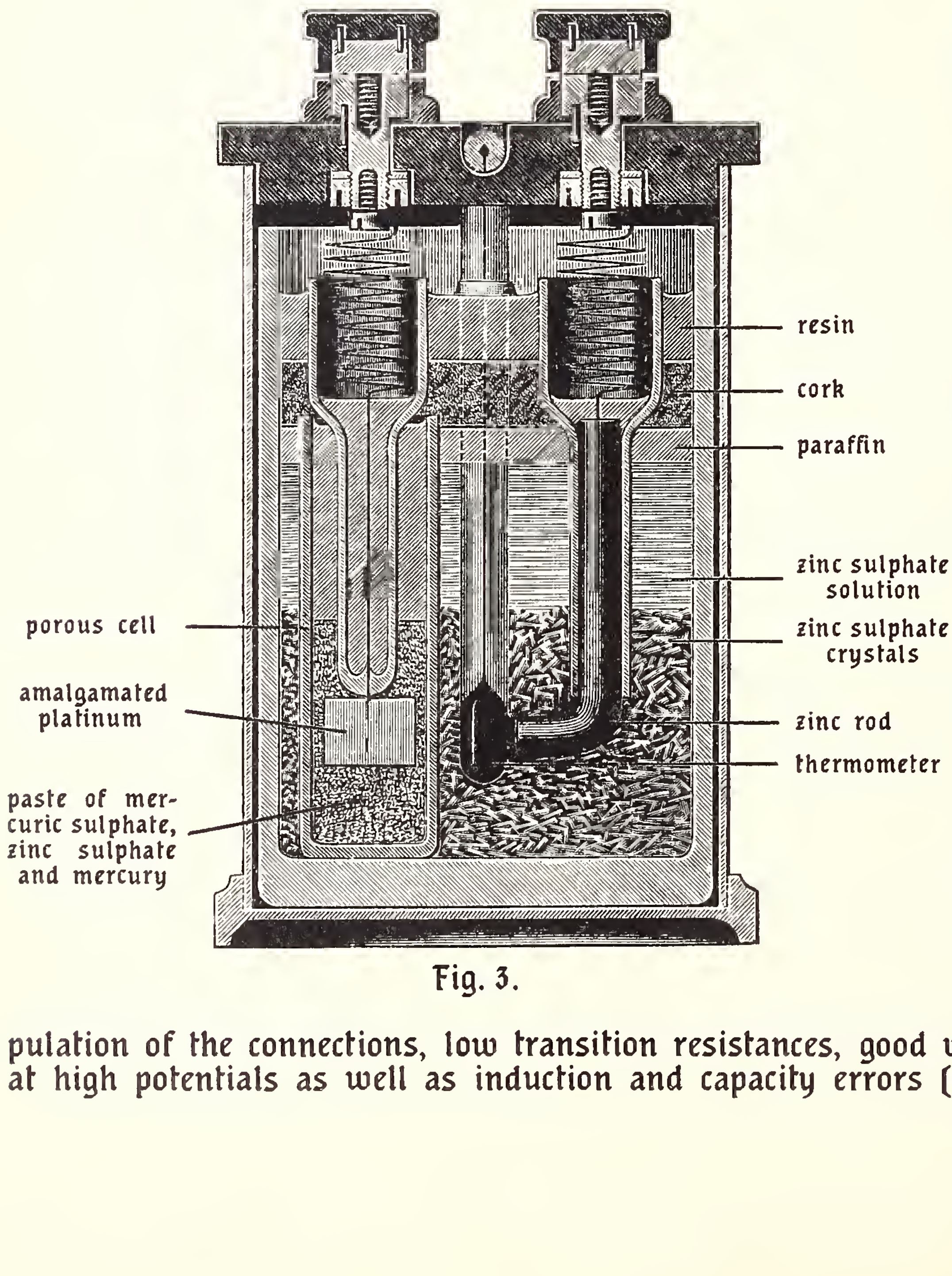

Fig. 3.

26. **Portable Clark and Weston Standard Cell,** pattern of the Imperial Institute. Clark's cell, as described by K. Feussner, Neuere Arbeiten der Physik.-Techn. Reichsanstalt (Recent works of the Imp. Phys. and Techn. Inst.), Collection of electrotechnical lectures, published by E. Voit, 1. No. 3. p. 135.

27. **Rheostat with Mica Sheet Resistances** made by O. Wolff, of Berlin. The resistances consist of covered manganine wire wound in single layers upon mica sheets. The connections are made by five or six covered sliding contacts fitted with brushes of fine silver foil, the readings being obtained from a series of numbered spring indicators situated on the inclined front of the box (Fig. 4).

The object of this new design is to obtain rapidity and certainty in the manipulation of the connections, low transition resistances, good ventilation, and to obviate short-circuiting at high potentials as well as induction and capacity errors (see K. Feussner, Neue Formen elek-

trischer Widerstandssätze (New forms of electrical resistance boxes), Elektrotechn. Zeitschr. 20. p. 611. 1899.

28. **Resistance Box for Powerful Currents,** with four decades and crank changer. The resistance coils consist of constantan strips, the greater portion of which are pressed between pairs of copper strips covered with mica both for protection and for the better abduction of heat. The four decades of 0.1, 1, 10 and 100 ohms are protected by an outside safety resistance of 5 ohms, by virtue of which the cranks may be changed at pleasure when the box is put into a circuit of 120 volts without risk of damage to the apparatus. In those cases where the circuit includes other sufficiently large resistances, the safety resistance coil, or one half of it, can be short circuited. See K. Feussner, Neue Formen elektrischer Widerstandssätze (New forms of resistance boxes), ibid.

29. **Regulating Resistance Box for Potential and Power Meters.** The resistances are similar in form to No. 27. The meters are put in and out of circuit, and the outside resistance adjusted gradually, by means of the main crank. An adjustable stop plug fixes the limit of the crank movement in each case. The commutator situated above the centre of the main crank serves for reversing the direction of the current in the meters. See K. Feussner, Neue Formen elektrischer Widerstandssätze (New forms of electrical resistance boxes), ibid.

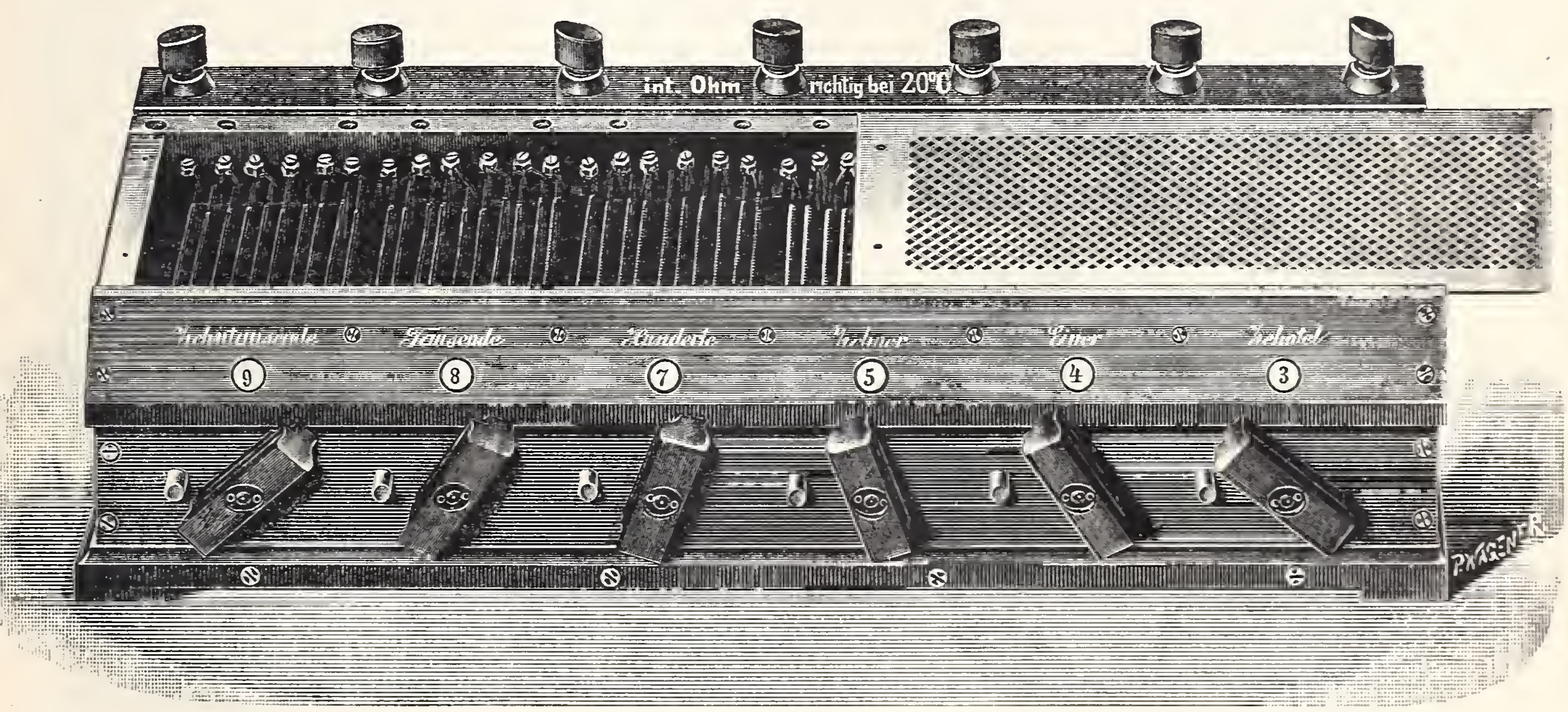

Fig. 4.

30. **Non-inductive Shunt Resistance for Alternating Currents.** Induction is obviated by bending the resistance strips into a loop, the closely packed halves being separated by a mica leaf.

31. **Reflecting High Potential Electrometer,** after the principle of V. Bjerknes's plate-electrometer (Wied. Ann. 48. p. 594. 1893), made by M. Bornhäuser, of Charlottenburg. The apparatus is adapted for measuring alternating potentials of several thousand volts and has for this purpose been standardized by a high potential battery.

32. **Feussner's Electrical Brake,** for determining the power of small electromotors, one pattern being a small one for powers not exceeding 0.2 horsepower, and a large model for powers up to 10 horsepowers.

The apparatus consists of a revolving copper disk, fitted with a water cooling arrangement, which should either be coupled to the motor or mounted direct upon the spindle. A magnetic system resting upon a knife-edge is maintained in equilibrium against the turning momentum of a weight by the attraction between the magnet poles and the eddy currents set up in the copper disk, this condition being brought about by the adjustment of the exciting current.

33. **Mounted Glass Tube for Ohm Determinations.** Five tubes of this kind have served for establishing the German unit of resistance in accordance with its legal definition. The ends of

the tubes are ground plane and fitted with spherical terminal vessels provided with the necessary platinum connections for passing the current through and for measuring the fall of potential. As shown in Fig. 5, the tubes are placed upon a rail within a copper box filled with petroleum and maintained at 0° C. by means of ice packing. The tubes have been carefully examined with respect to bore, length and section and are periodically compared with each other and with their copies so as to establish and maintain a fundamental standard for the resistances submitted for certification. See Wiss. Abh. d. Reichsanstalt 2. p. 379. 1895, and 3 (in the press); also Wied. Ann. 64. p. 456. 1898 and Z. f. Instrk. 16. p. 134. 1896 (Extract).

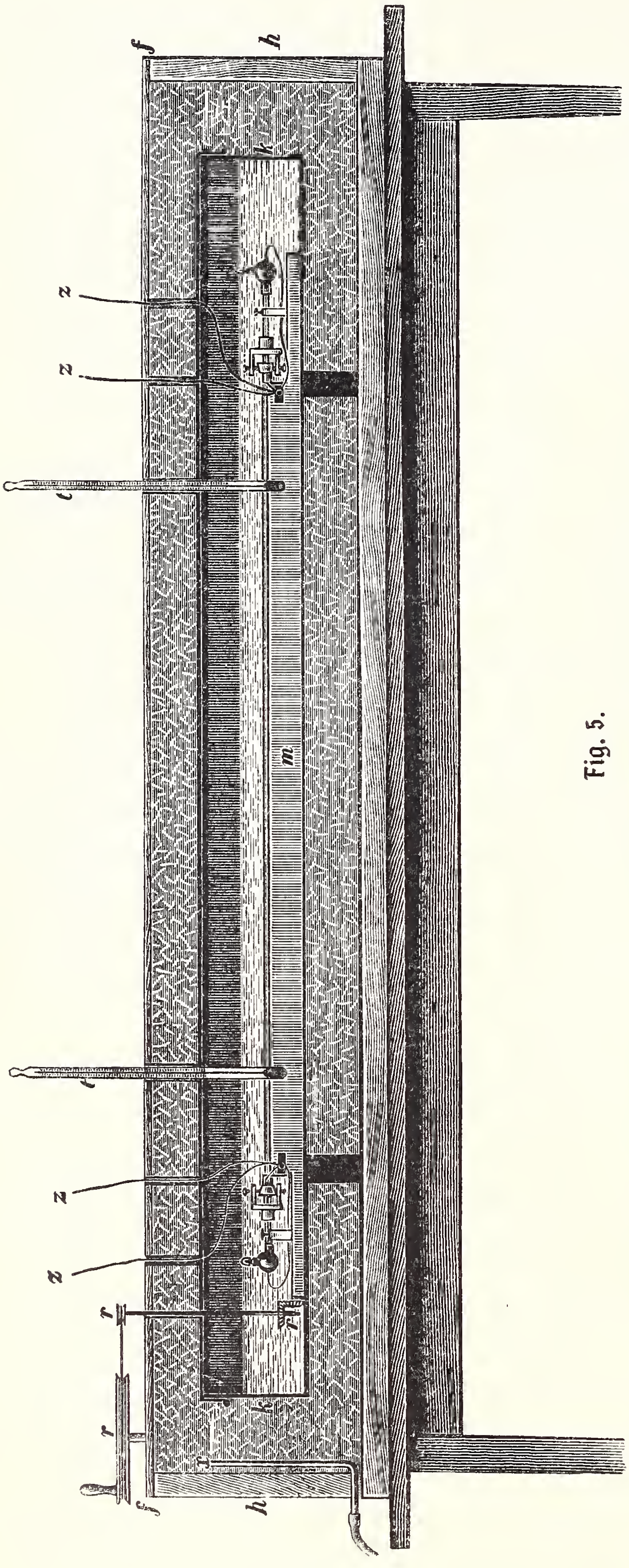

Fig. 5.

34. Ohm Copy. These copies consist of bent glass tubes with terminal vessels, they are filled with mercury under a vacuum and thereupon sealed. Like the standard tubes (No. 33), they are measured at 0° and are, for this purpose likewise immersed in petroleum at 0°. Each terminal vessel has fused into it three platinum connections, viz. for the passage of the current, for measuring the fall of potential and for the shunts. Periodical comparisons are made with the standard tubes and wire copies in order to verify the constancy of the unit of resistance serving as the basis of all regular tests. See Wied. Ann. 47. p. 513. 1892; Wiss. Abh. d. Reichsanstalt 2. p. 437. 1895, and Z. f. Instrk. 16. p. 134. 1896 (reprint); also Wied. Ann. 64. p. 484. 1898; Z. f. Instrk. 18. p. 99. 1898 and Wied. Ann. 65 p. 576. 1898.

35.[1] Standard Resistances of Manganin Wire from 0.1 to 100,000 ohms. These resistances serve both the purposes of exact standards for measuring resistances and for determining strengths of currents by measuring the difference of potential at the two ends of the coil. The coils were constructed so as to satisfy the following requirements:—The resistance should undergo as little periodic changes as possible; the temperature of the wire should be accurately ascertainable; the generation of thermo-electric currents should be obviated; the heat produced by the current should be carried off as rapidly as possible. The wire coils are artificially aged before the final adjustment by being exposed for 10 hours to an air-bath at 140° C. The other requirements are satisfied by the design of the apparatus, as shown in Fig. 6. The copper electrodes have two bends having attached to them the resistance box immersed in petroleum. See Feussner and Lindeck, Z. f. Instrk. 9. p. 233. 1889. Feussner, ibid. 10. p. 6. 1890; Feussner and Lindeck, ibid. 15. p. 394. 1895 and Wiss. Abh. d. Reichsanstalt 2. p. 503. 1895. Jaeger and Lindeck, Z. f. Instrk. 18. p. 97. 1898.

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[1]) Nos. 35 to 39 have been lent for exhibition by O. Wolff, of Berlin, together with certificates by the Imperial Institute.

36. Resistances of Manganin Strips of 0.01, 0.001 and 0.0001 ohm. These resistances are made in two sizes. The smaller pattern is represented by two resistances of 0.01 and 0.001 ohm. They are adapted both as standards for measuring resistances (e. g. for balancing other resistances of a similar value, for measuring the conductive power of copper rods, &c.), and also for measuring the strength of currents by the indirect method. In the latter case they can be worked up to 100 watts, provided they are contained in appropriately constructed petroleum-baths. The larger model is adapted for measuring very large currents and is available for 1,000 watts; two resistances of 0.001 and 0.0001 ohm respectively are exhibited. The petroleum is well stirred by a central turbine and is kept cool by a stream of cold water passing through a spiral.

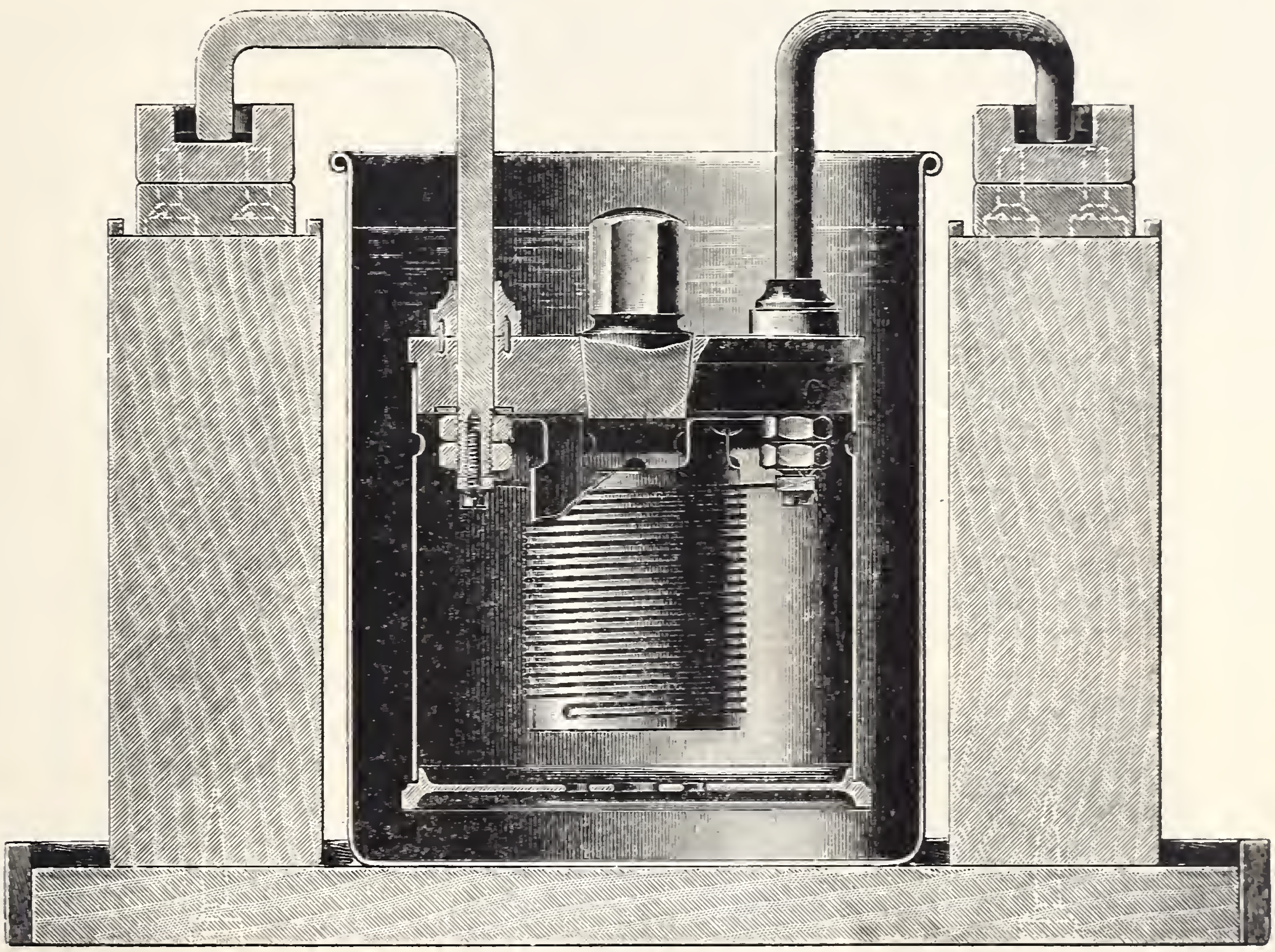

Fig. 6.

When adjusting these resistances the strips are initially given a smaller than the required resistance and subsequently their section is diminished by boring holes into them until the correct resistance is obtained. By this method it is not difficult to adjust a resistance of 0.0001 ohm within the ten thousandth part of its value. See Feussner, Z. f. Instrk. 10. p. 425. 1890.

37. Plug Resistance Box of 0.1 to 50,000 ohms. This resistance box is constructed after the pattern of Siemens's plug resistance boxes, but due regard is paid to the requirements set forth in the description of the single resistances. The coils are made of manganin; each coil being artificially aged by heating and the internal connections are exclusively obtained by soldering. In addition to the holes for the travelling plugs, the contact pieces are provided with screws, which is frequently a great convenience when accurate measurements are to be made with the box.

38. Potentiometer with Outside Resistance Box. This apparatus is a new form of the potentiometer described by Feussner (Z. f. Instrk. 10. p. 113. 1890). It is adapted for measuring, with the aid of standard cells, e. g. Clark's or Weston's, of accurately known electromotive force, the potentials of continuous currents, from the lowest to the highest voltages, with a degree of accuracy within 0.1 per cent. With the aid of known resistances, e. g. the small re-

sistances described under No. 36, the apparatus is likewise available for measuring with a similar degree of accuracy, the strength of continuous currents. The measurement is generally made in such a manner that the apparatus gives direct readings of the potential. The apparatus is roughly represented in Fig. 7, from which it will be seen that it contains five sets of crank resistances, viz. 9 resistances of 1,000 and 100 ohms each and 2×9 resistances of 10, 1 and 0.1 ohm. The resistance of the entire apparatus between the terminals +B and —B at any position of the cranks is nominally always 14,999.9, or roughly 15,000 ohms.

The measurements of high potentials necessitates the use of an outside resistance. No. 27 may be employed for this purpose.

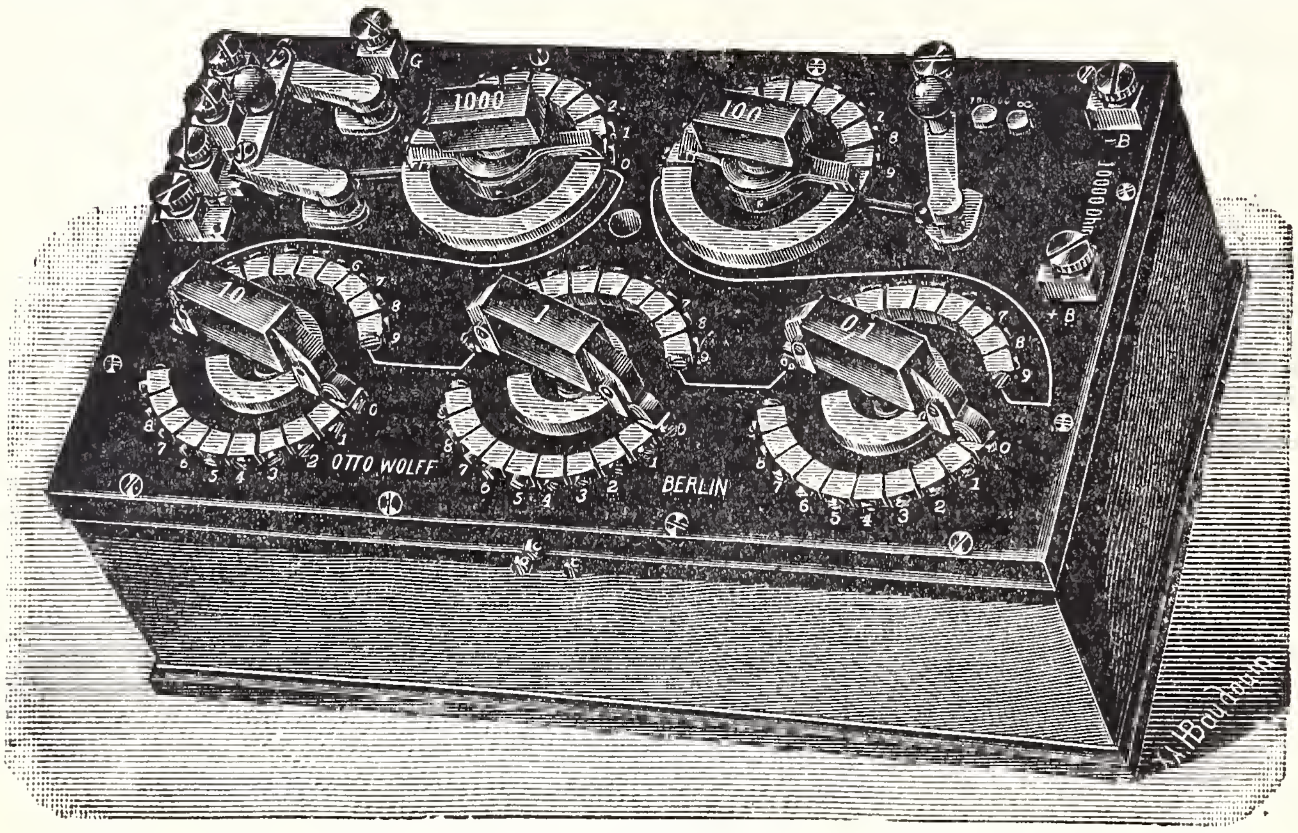

Fig. 7.

39. Double Shunt Box with Arrangement for Ascertaining the Conductivity of Copper Rods, &c. The conducting power of thick copper wires is determined at the Imperial Institute by Thomson's double bridge method. In contradistinction to the apparatus generally employed for this purpose the standard resistances are invariable (e. g. 0.001 ohm) and the shunt resistances variable. Two knife-edges are placed upon the wire to be measured at points exactly 50 cm apart and the ratio of the resistance of this section to the standard resistance is ascertained by the double resistance box. For this purpose the apparatus is provided with three plug resistance coils of 100, 50 and 25 ohms respectively and four shunt decades of sliding resistances each comprising 9 coils reading to 0.1, 1, 10 and 100 ohms. The connecting resistance between the nearest knife-ekge and the standard resistance is bridged in the usual manner, the number of plug and sliding resistances being exactly the same as that in the variable branches. The corresponding decades of the two circuits are opposite each other and put in and out of circuit by the same double lever.

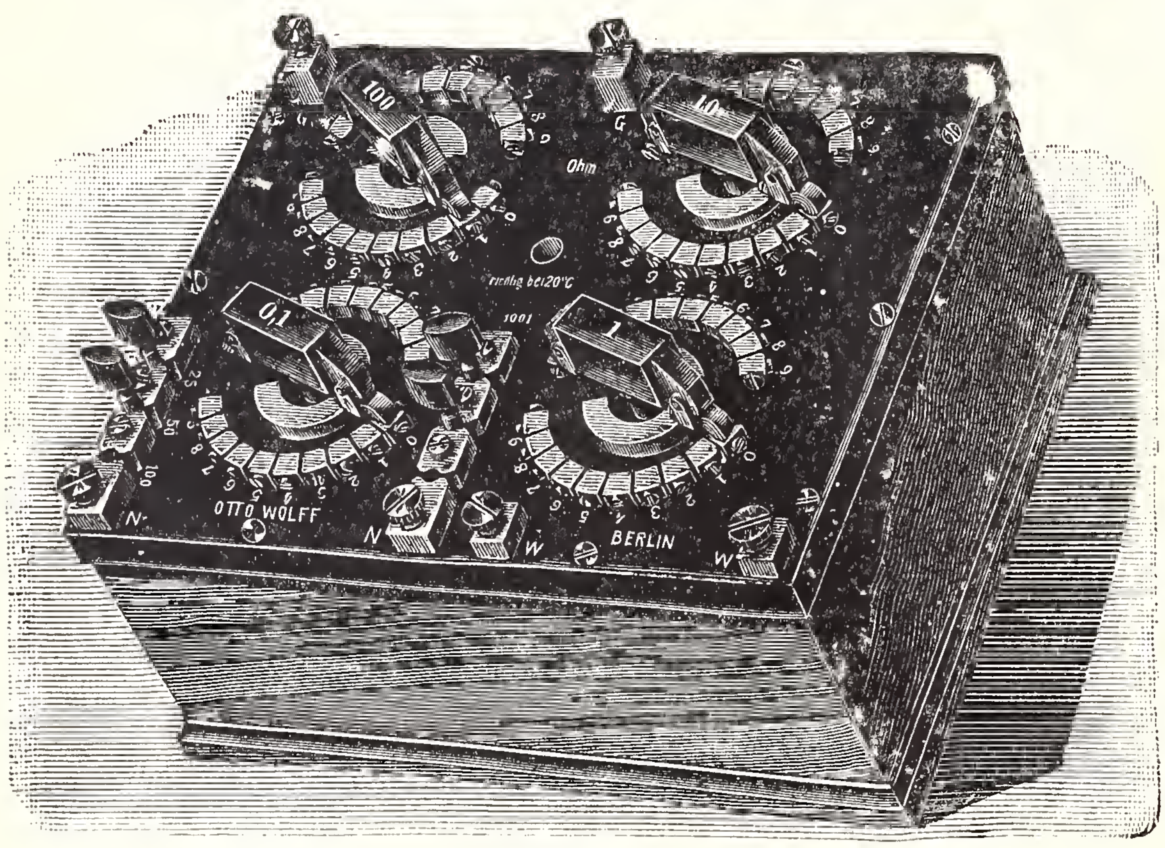

Fig. 8.

While measuring, the copper bar is immersed in a petroleum bath which can also be made to contain the standard resistances (e. g. 0.01, 0.001 and 0.0001 ohm). The petroleum is kept in agitation by small turbines and can be heated electrically above the ordinary temperature for the purpose of ascertaining the temperature coefficient of the copper. See Feussner, Collection of lectures on applied electricity, edited by E. Voit, 1. No. 3. p. 118. 1897.

40. Comparison Apparatus for Standard Resistances of approximately equal value. The resistances which are to be compared are placed in oblong petroleum baths, one of which can be heated electrically. The ratio of the two resistances is determined with the aid of a shunt-box. The latter contains two high side resistances, say of 100 ohms, and between both a resistance measuring the thousandth part of each side coil, in this instance 0.1 ohm. The connecting resistance between the resistances which are to be compared is bridged by a similar box after Thomson's method. This is particularly important when the resistances under comparison do not exceed 1 ohm. It is easy by this arrangement to attain a degree of accuracy within a few millionths of the value. A description of the apparatus and the manner in which it is used will be found in the third and fourth reference given at the conclusion of No. 35.

41. Four-crank Outside Resistance Box for regulating the measuring current, as well as for many other measuring operations. It embraces four decades of 9 resistances in each (say of 0.1, 1, 10, 100 or 1, 10, 100, 1,000 ohms, &c.), which can also be split up into two parts for use in two separate circuits.

42. Kundt's High Resistances. At the instigation of Prof. Kundt a series of experiments have been carried out in the Imperial Institute in the course of the last few years with a view to ascertain whether his process of burning extremely thin layers of platinum and platinum alloys into glass or porcelain could be utilized as a means of constructing very high resistances. These experiments were carried out in conjunction with the Chemical Works Limited (late E. Schering), Berlin. The exhibits include a smooth porcelain cylinder, another coated with an alloy of platinum and a complete resistance. The latter is made by the following process:—A cylinder completely covered with the alloy is coated with a thin layer of wax. A spiral of appropriate pitch is cut upon this layer with a knife and with the aid of a lathe, whereupon the exposed layer of platinum is removed by acids; or a screw thread may be drawn upon the porcelain cylinder with a drawing pen charged with the platinum solution and then burnt in. This method is likewise represented by a resistance of roughly 300,000 ohms.

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